JULY 1954

Journal

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AMERICAN WATER WORKS ASSOCIATION

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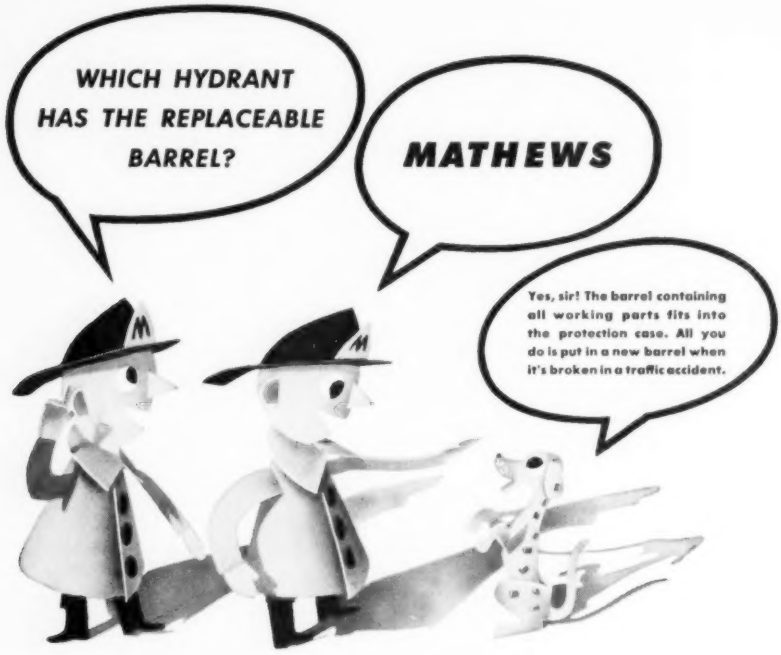
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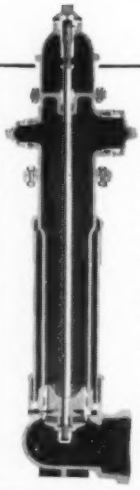

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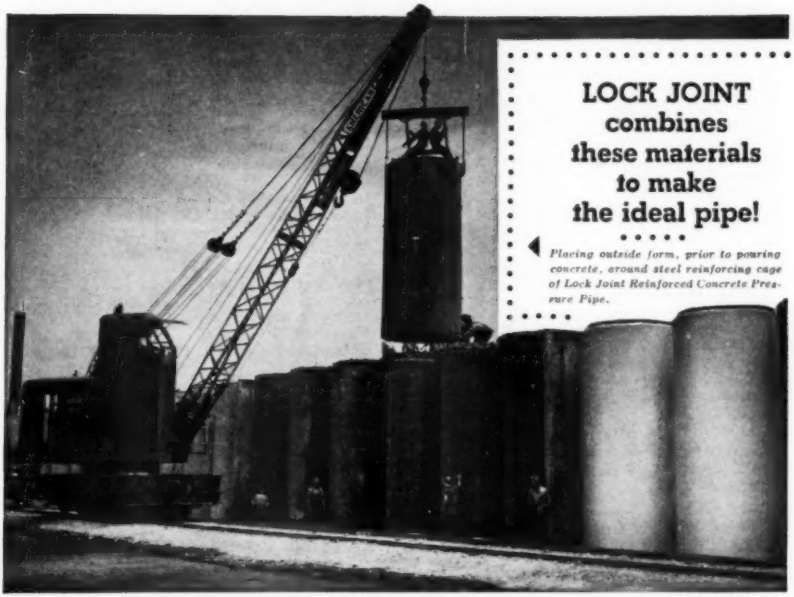

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Coming Meetings

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Chicago, Ill. June 12-17, 1955

AWWA SECTIONS

Sept. 9–10—New York Section at Montauk Manor, Montauk, L.I. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50th St., New York 20, N.Y.

Sept. 15–17—Michigan Section at Occidental Hotel, Muskegon. Secretary, T. L. Vander Velde, Chief, Secretary of Water Supply, State Dept. of Health, Lansing 4, Mich.

Sept. 20–22—Kentucky-Tennessee Section at Andrew Jackson Hotel, Nashville, Tenn. Secretary, J. Wiley Finney Jr., Asst. Director, Div. of San. Eng., State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

Sept. 22–24—Ohio Section at Biltmore Hotel, Dayton. Secretary, M. E. Druley, Manager, Dayton Power & Light Co., Wilmington, Ohio.

Sept. 26–28—Missouri Section at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

Sept. 28–30—Wisconsin Section at Hotel Northland, Green Bay. Secretary, Leon A. Smith, Supt. Water & Sewerage, City Hall, Madison 3, Wis.

Oct. 6–8—Minnesota Section at Lowry Hotel, St. Paul. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Oct. 13–15—Iowa Section at Hotel Roosevelt, Cedar Rapids. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

Oct. 17–20—Southwest Section at Cortez Hotel, El Paso, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

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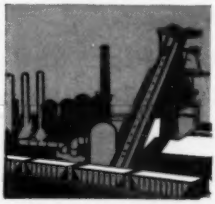
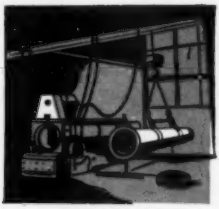
Ore and Coal Mines

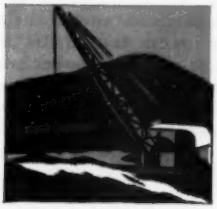
Coke Ovens



Blast Furnaces



Pipe Plants



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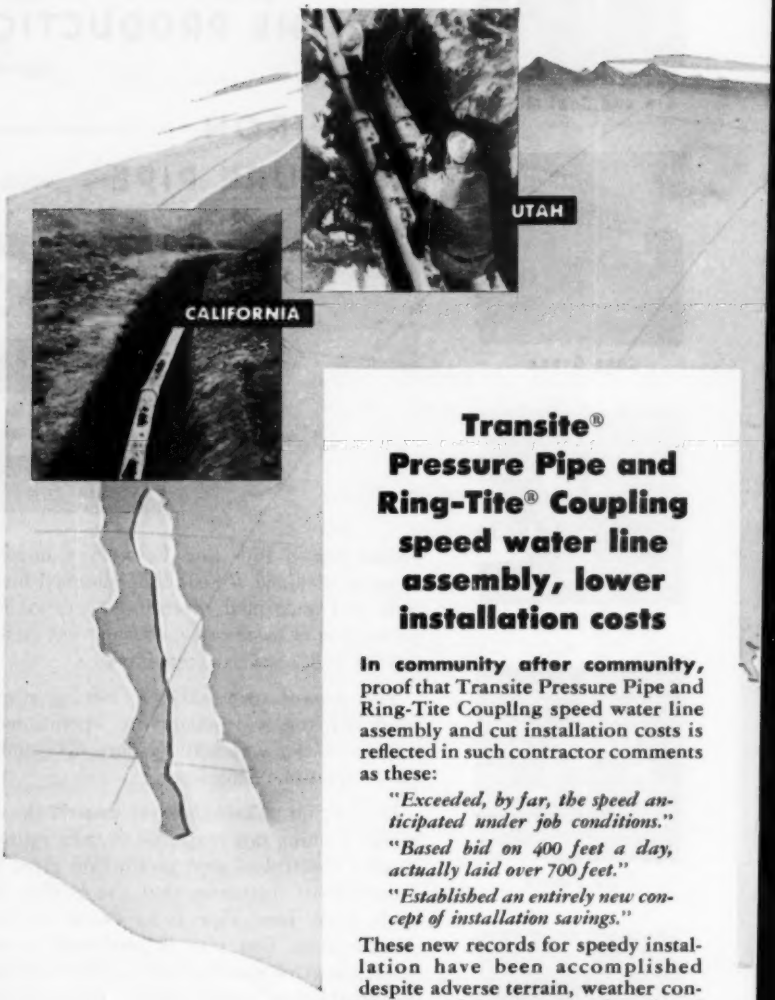

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Coming Meetings

(Continued from page 6)

Oct. 24–27—Alabama-Mississippi Section at Tutwiler Hotel, Birmingham, Ala. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 26–29—California Section at Wilton Hotel, Long Beach. Secretary, Henry Franklin Jerauld, Asst. Supt. of Constr. & Operation, Water Dept., 1040 Manzanita, Pasadena 3, Calif.

Oct. 27–29—Chesapeake Section at Belvedere Sheraton Hotel, Baltimore, Md. Secretary, Carl J. Lauter, 6955 —33rd St., Washington 15, D.C.

Nov. 3–5—Virginia Section at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, 213 Carlton Terrace Bldg., Roanoke 11, Va.

Nov. 4–6—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan, Inc., Box 178, Newark 1, N.J.

Nov. 7–10—Florida Section at Soreno Hotel, St. Petersburg. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica-Burnett Chemical Co., Box 2328, Jacksonville, Fla.

Nov. 8–9—West Virginia Section at Prichard Hotel, Huntington. Secretary, H. K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

Nov. 8–10—North Carolina Section at George Vanderbilt Hotel, Asheville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

Nov. 9–10—Rocky Mountain Section at Broadmoor Hotel, Colorado Springs, Colo. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Dec. 2–4—Cuban Section at Sociedad Cubana de Ingenieros, Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

OTHER ORGANIZATIONS

Jul. 25–31—Inter-American Conference of Sanitary Engineering (AIDIS), in Sao Paulo, Brazil.

Aug. 2–12—Pan American Federation of Engineering Associations (UPADI) at Sao Paulo, Brazil

Sep. 28–30—South Dakota Water & Sewage Works Conference, in Mitchell, S.D.

Oct. 3–6—New England Water Works Assn., Poland Springs, Me.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.

Oct. 11–15—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–20—Public Utilities Sessions, National Safety Congress, Chicago

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York

Cochrane solids-contact reactor

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for municipal use

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New HINGED PIPE CUTTER

You can cut off 8" pipe, *in less than 5 minutes*

send for free literature on these amazing cutters for standard steel and cast iron pipe from 2½" to 12".

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Without obligation, please send me descriptive literature on your new hinged pipe cutters.

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Triangle Brand Copper Sulphate

HELPS SOLVE YOUR WATER PROBLEMS

Triangle Brand Copper Sulphate economically controls microscopic organisms in water supply systems. These organisms can be eliminated by treatment of copper sulphate to the surface. Triangle Brand Copper Sulphate is made in large and small crystals for the water treatment field.

Roots and fungus growths in sewage systems are controlled with copper sulphate when added to sewage water without affecting surface trees.

Booklets covering the subject of control of microscopic organisms and root and fungus control will be sent upon request.

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NICHOLS TRIANGLE BRAND CHEMICALS

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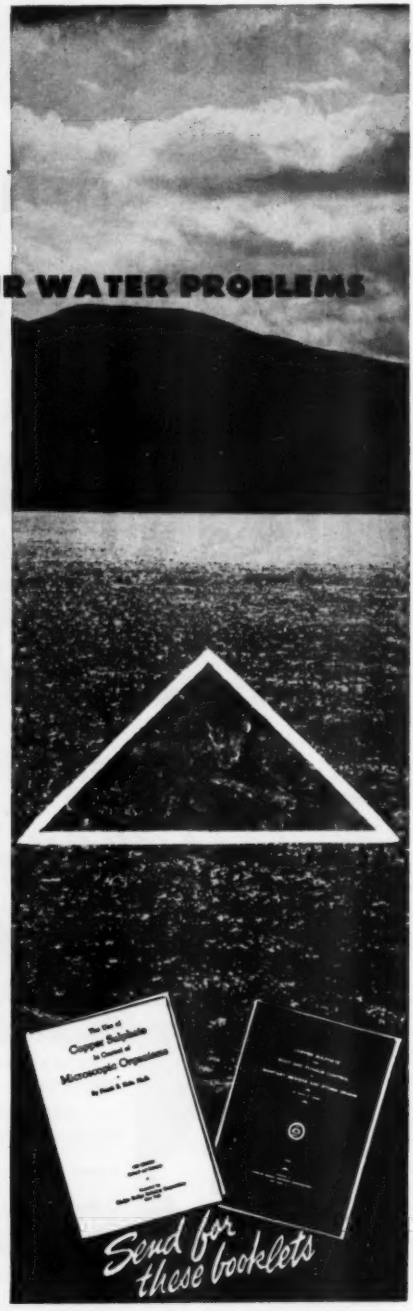

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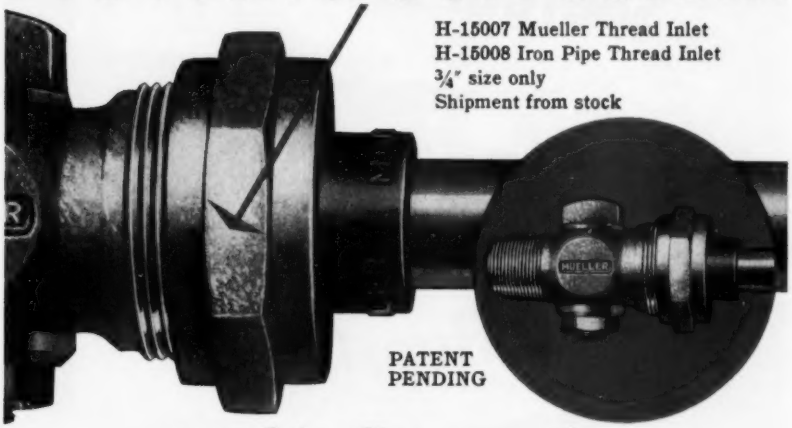

H-15007 Mueller Thread Inlet
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The Insulating Outlet Corporation Stop is easily installed in the main, under pressure, with the Mueller "B" Machine. Copper service pipe is flared with standard tools to prevent pull-out. Coupling needs only minimum tightening for a perfect seal.

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Dependable Since 1857

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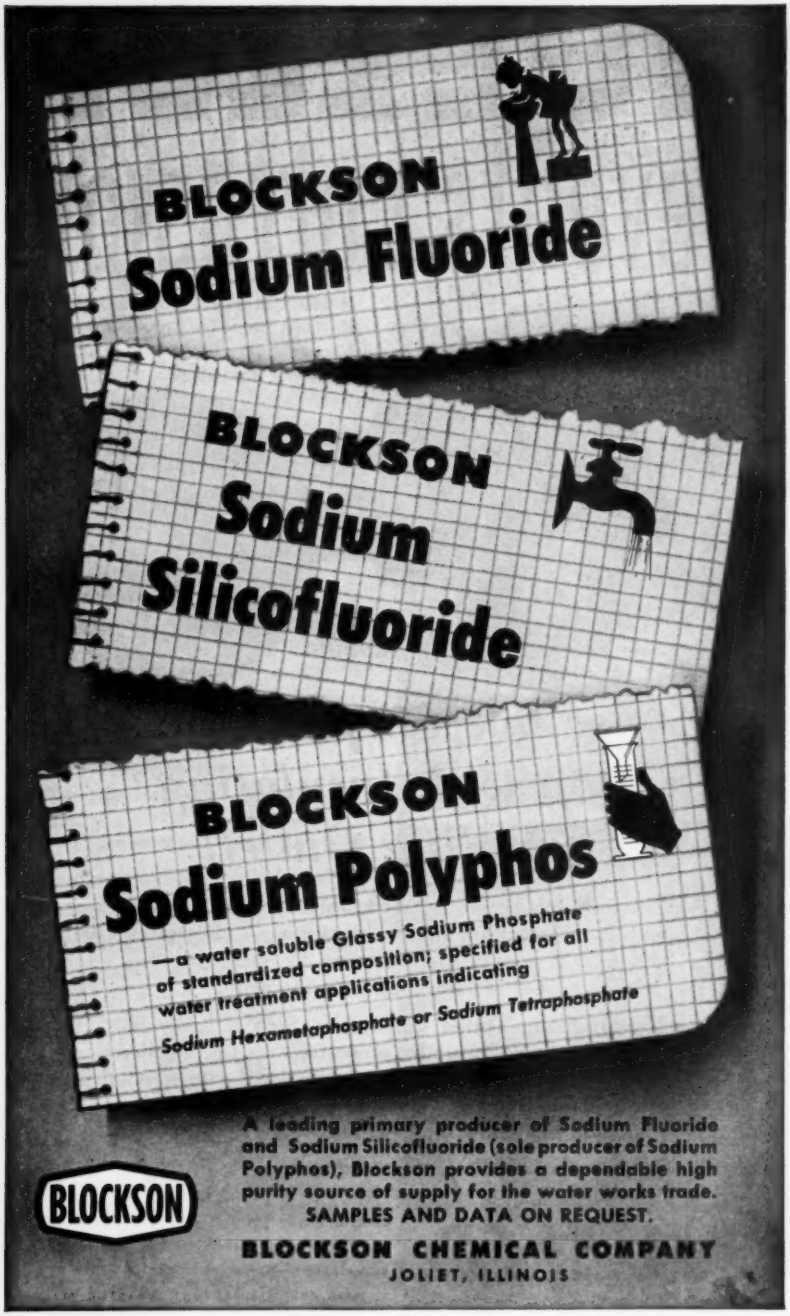
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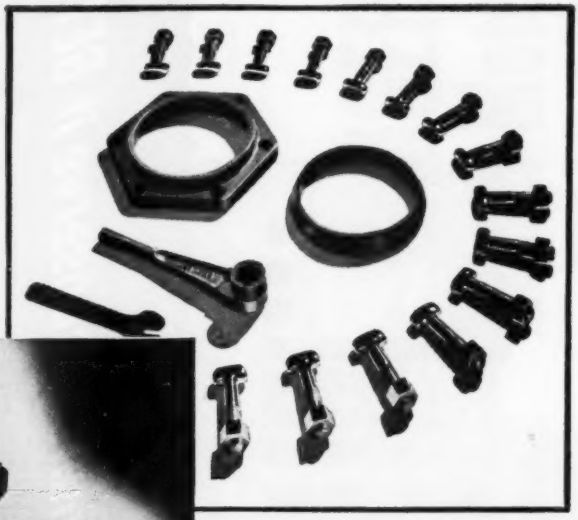

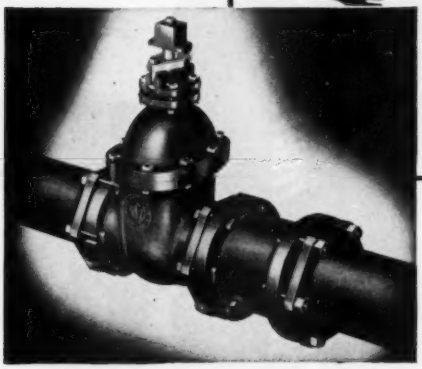

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The Cut In Valve can be installed rapidly, in fair or stormy weather on Cast Iron A.W.W.A. and Federal specification water mains, by unskilled labor, using only two wrenches.

Moulded rubber gaskets fit into machined "Stuffing Box" type joints, guaranteeing a permanent leak-proof seal.

Smith Cut In Valves are manufactured in compliance with the A.W.W.A. Gate Valve specification, and all parts are interchangeable with like parts of Smith A.W.W.A. Gate Valves.

Write for Bulletin No. MJ2.

37

FIRE HYDRANTS VALVES SINCE 1896

THE A.P. SMITH MFG. CO.

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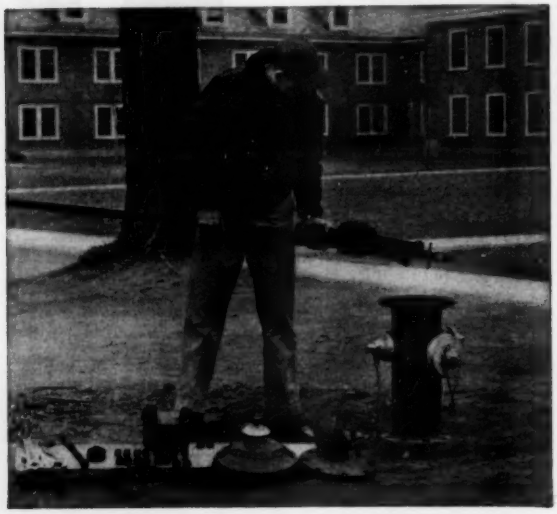
Water is vital...
BADGER meters conserve it BETTER!

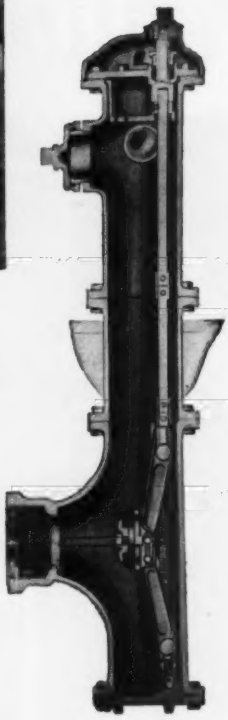
SANITATION is so vital to life that a city of three-quarters of a million people actually uses 134,000,000 gallons of water daily! In thousands of communities, famous Badger meters make certain that homes and industrial projects get their fair share of the supply . . . pay only for the water they use. Badger meters measure water precisely . . . help eliminate waste . . . make water departments more efficient and self-supporting. And, as waterworks men verify, Badger meters do the job dependably . . . serve for years with little or no attention.

BADGER
Water Meters

Badger Meter Mfg. Co.
Milwaukee 45, Wisconsin

"Measures the water of the world"





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WITH RENSSELAER

The illustrations show how easy it is to remove and inspect the entire mechanism of the Rensselaer-Corey Fire Hydrant which has been the standard in many cities for more than half a century.

The parts can be removed, inspected, and replaced in twenty-two minutes. No digging for repairs or for standpipe breakage. This hydrant opens with the pressure, by means of the powerful knuckle joint. Easy to operate and cannot stick. It is quick opening with free flow long radius curves. Hydrant will not flood.

Ask for Catalog No. G and see why the Rensselaer-Corey Hydrant is preferred by superintendents, fire chiefs and maintenance men. 106D

Rensselaer VALVE CO. TROY, N. Y.

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SALES REPRESENTATIVES IN PRINCIPAL CITIES

GENERAL FILTER'S

case history files

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ANY *water conditioning* PROBLEM

Granted . . . no two water treatment problems are ever exactly alike. Every installation requires individual, specialized attention . . . the composition of the water, rate of flow, local conditions and desired results must all be studied before recommendations are made. However, our authentic case history files of thousands of different installations may cover many of the problems you encounter. A problem that is new to you may be old to us. Save valuable time by checking with General Filter Company first on your water treatment problems. There's no obligation and we'll be glad to give you all the help we can. Write us today!

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FOR 100 YEARS

Photo:
Ewing Galloway

This is Chicago, second largest city in the U. S. A.—population over 3½ million.

Print:
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A view of Lake Street, Chicago, as it looked 100 years ago.

MODERNIZED **cast iron**

they've been coming back for more...

CHICAGO installed cast iron water mains 100 years ago... and installs them today!

Chicago's skyline has changed magically in a century but the underground lines that transport water are still cast iron. Nearly 100% of her water distribution system consists of cast iron pipe. This city of "magnificent distances" has over 4,000 miles (21 million feet) of cast iron mains, supplying more than one billion gallons of water per day to a population approaching four million.

Section of a century-old cast iron main still serving in Chicago's vast water distribution system.

A famous jurist defined *good will* as the "probability of the customer's returning to the old stand." Chicago's Water Department has been coming back for more cast iron pipe for 100 years. That's good will—yes—built on proved performance. Chicago has century-old cast iron pipe in its water distribution system.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher, and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

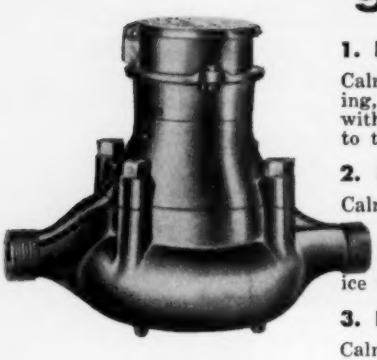
Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3.

CAST Q IRON

The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe FOR MODERN WATER WORKS OPERATION

THIS METER gives you



1. PRECISION ACCURACY

Calmet's oscillating piston is semi-floating, precision balanced, and measures with precision accuracy the various flows to the smallest drip.

2. EXTREME LONG LIFE

Calmet's slower moving piston and gear train means less wear on precision parts, hence long life accuracy. Its simple design assures years of service with a minimum of attention.

3. LOW UPKEEP

Calmets are easy to take apart, easy to repair. The split case design with spuds in the base permits quick removal of working parts for cleaning or inspection without breaking the line connection.

4. FROST PROTECTED

When the meter freezes or pressure exceeds 450 pounds, Calmet's exclusive FROST PROOF BOLTS provide maximum protection against damage to working parts.

"THE METER YOU CAN COUNT ON"

CALMET

MANUFACTURED BY WELL MACHINERY & SUPPLY CO., INC.
FORT WORTH, TEXAS

When you buy HYDRANTS and VALVES for your city waterworks system...

LOOK TO THE YEARS AHEAD, TOO!

EDDY can supply replacement parts for any Eddy Valve or Hydrant ever installed! This is important to you because the Valves and Hydrants you buy today must serve several generations yet unborn. You want no "orphans" in your system. Eddy Hydrants and Eddy Valves are backed by Eddy Valve Company's 104 years of dependable operation—your assurance that replacement parts will be available during the years to come.

EDDY Bronze-Mounted HYDRANTS are built for dependability and lasting service. They open smoothly *with* the pressure and close without water hammer. One man can easily remove all operating mechanism for inspection and repair. Positive drip action automatically drains the standpipe, safeguarding against freeze-ups. Stem held in place below main valve means no water loss due to a bent stem.

EDDY Bronze-Mounted GATE VALVES offer simplicity of design, trouble-free operation and enduring service. From the engineering drawing boards through all stages of manufacture, they are step by step a truly "finished" product of workmanship. These factors, added to personal experience, are reasons why progressive water works men have relied on Eddy Valves for years.

Eddy Hydrants and Valves are available with bell, flange or mechanical joint connections to fit any existing or planned installation.

Send today for full information on the complete line of Eddy Valves and Hydrants. No obligation.

EDDY VALVE COMPANY
A Subsidiary of James B. Clow & Sons
WATERFORD, NEW YORK

WORTHINGTON-GAMON

WATCH DOG

The meter used by thousands of municipalities in the U. S.

WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

Worthington Corporation

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OFFICES IN ALL PRINCIPAL CITIES

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Since 1934, by using cement lining in its trunk mains, Newark's water flow has been boosted from 57 to 83 million gallons a day.

This was made possible by converting old pipes into new—free of tuberculation and interior corrosion. Here's how it was done: old pipes were hydraulically cleaned, centrifugally machine-lined with mortar cement and smoothed to an even surface. The result: distribution pressure and carrying capacity greatly increased, maintenance costs substantially lowered and life expectancy of pipes extended indefinitely. Entire process done with pipes in place at a *fraction* of the cost of laying new pipes.

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A subsidiary of Raymond Concrete Pile Co.

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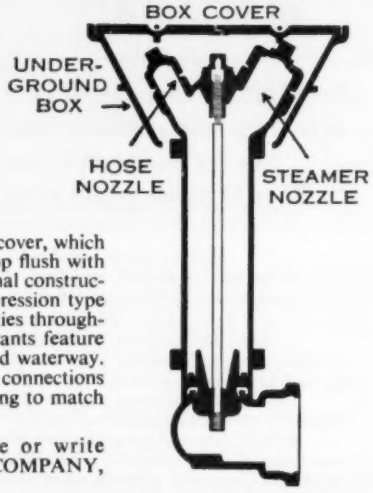
Branch offices in Principal Cities of United States and Latin America

3,000,000 FEET OF EXPERIENCE

Write today for booklet!

CEMENT-MORTAR LINING OF PIPES IN PLACE



This M & H Hydrant sets completely underground. The cast iron box cover is on line with the ground level, thus completely eliminating any interference with traffic. M & H flush type hydrants are especially designed for use at airports servicing the heaviest modern airplanes.

The operating nut and nozzles are accessible simply by lifting the two piece cover, which has disappearing handles designed to drop flush with the cover when not in use. Hydrant internal construction is exactly the same as M & H compression type fire hydrants used by so many municipalities throughout the country. M & H flush type hydrants feature a 5¼" valve opening and an unobstructed waterway. Can be supplied with one or two fire hose connections and/or with steamer nozzle, with threading to match existing standards.

For additional information, wire or write M & H VALVE AND FITTINGS COMPANY, ANNISTON, ALABAMA.

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HIGH QUALITY WATER ★ LOW INSTALLATION COST ★ MINIMUM OPERATING ATTENTION

ACCELAPAK (Trade-Mark)
water plant is the answer

"ACCELAPAK" equipment makes "custom plant" water quality available with "standard package" convenience and economy for . . .
- Small communities
- Camps and resorts
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- Industrial plants, etc.

"ACCELAPAK" Water Plant includes:
- ACCELATOR® clarifier or softener
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- Filter – gravity or pressure
- Other components as required

Capacities: 15 g.p.m. to 250 g.p.m. and up

▶ *for full details*

on how the "ACCELAPAK" plant can provide you with high quality water, treated at a cost well within the budget, send this coupon now.

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TITLE_____
COMPANY_____
ADDRESS_____
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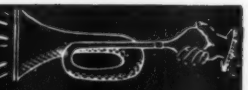
YOU WERE DOING THIS



WHEN THE FIRST HYDRO-TITE JOINTS WERE BEING POURED -

HYDRO-TITE (POWDER)

HYDRO-TITE

(POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

HYDRO-TITE (LITTLEPIGS)

HYDRO-TITE

(LITTLEPIGS)

The same dependable compound in solid form —packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX (REELS)

FIBREX

(REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

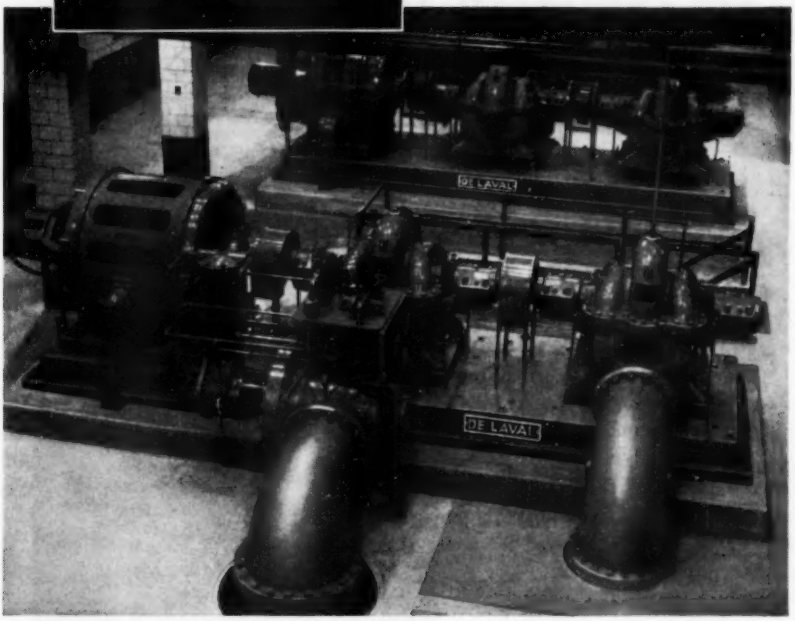
HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 30 Church Street, New York — General Office and Works: W. Medford Station, Boston, Mass.

DE LAVAL
CENTRIFUGAL PUMPS

bring 68% water reserve to Allentown, Pa.



These 15 mgd, 288 foot-head centrifugal pumps are among the total of nine De Laval units that provide a new, all-time high in water availability at Allentown, Pa. Full capacity is 42 mgd, present consumption 25 mgd—a "cushion" of 68% against the heavier demands of future years.

Part of the problem in setting up this big, new facility was to utilize as much equipment as possible from the old plant. Here, De Laval versatility paid off, for several units which had already been in use for twenty years tied in easily, economically, with the new system.

More than 80% of America's cities look to De Laval for the utmost in pump performance and dependability. And they profit daily from De Laval's 53 years of experience in municipal water works pumping. De Laval units range from 100 thousand to 100 million gallons per day.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

NOW DEPENDABLE CHLORINATION plus

Since 1913, Wallace & Tiernan has consistently offered the best in chlorination and chlorination equipment. Now . . . the new A-701, first of the W & T "700" series of chlorinators, and the most up-to-date chlorinator available today, offers these PLUS VALUES to assure safe and dependable chlorination:

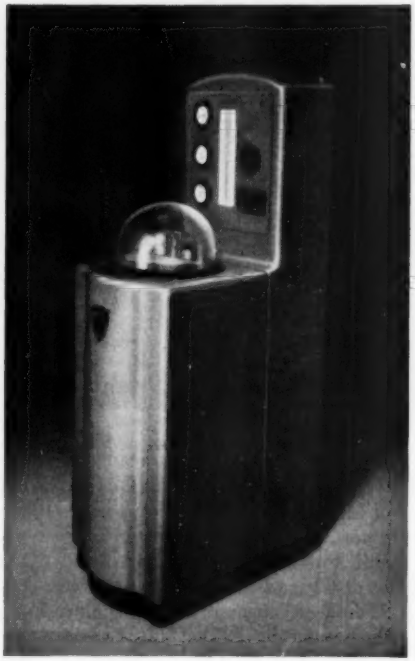
Feed ranges up to 100 to 1 without replacing meters.

Maximum corrosion resistance without sacrifice of structural design.

Linear scale reading of chlorine flow rate.

May be operated by manual control, or automatically by electric, hydraulic, air pressure or air vacuum control.

Feed rates up to 1000 pounds per 24 hours.



S-90

For the best in equipment, look for the PLUS VALUES that add up to Dependable Chlorination.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, N. J.

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 46 • JULY 1954 • NO. 7

The Problem of Water Resources

By L. K. Sillcox

Excerpts from an address presented on Apr. 22, 1954, at the New York Section Meeting, Watertown, N.Y., by L. K. Sillcox, Pres., American Society of Mechanical Engrs. and Vice-Chairman of the Board, New York Airbrake Co., New York.

COUNTLESS millions of people are in want; actually hundreds of millions throughout the world are balanced on the starvation line. World-wide communication causes them to hear and dream of the magic that is freedom or liberty. They are all well aware of the material resources that are required to nurture it. The determining question in the future of civilization is whether the supply of resources to be gained from the earth can prove adequate not only to meet the basic needs of the people but to support the complex requirements of modern culture and economy. What we call the "free world" has it in its power to find the answer to this primal question. To succeed, we must clearly understand the facts regarding existing and potential resources. Equally, the facts regarding populations, their growth and pressures, must be appraised and dealt with deliberately and clearly. It is needless to debate which of these two problems is the more immediate, or the more critical. The destiny of man depends upon the resolving of both. When resources have proved adequate not only to meet the basic needs of peoples but also to support their economies, nations and cultures have flourished. The so-called great periods of history are intimately identified with such a favorable relationship; lacking it, apparently indestructible empires have vanished.

Water Demand

There is an element in our natural-resource picture that is commencing to reach a critical point. This is water supply. With the surprise that comes from any new experience, some 40,000,000 Americans, living in various regions and communities, are now actually face to face with problems of water—either those of real shortage or of unsatisfactory quality, or both. During the last half century our per capita

consumption of water has doubled, and, in view of the fact that our population has also doubled during this period, it is is evident that our water needs have increased fourfold since 1900. Although part of this is due, of course, to domestic and municipal demands, the larger part is brought about by the tremendous drafts that are being placed on available water by the expansion of industry and the extension of agriculture, including huge irrigation projects.

TABLE 1

Water Use, 1950

17 Western States		31 Eastern States	
State	Quantity *bgd*	State	Quantity *bgd*
California	22.3	Illinois	9.9
Idaho	13.8	New York	9.6
Colorado	8.9	Ohio	9.3
Arizona	6.0	Pennsylvania	7.0
Texas	5.9	Michigan	5.9
Montana	5.1	West Virginia	3.5
Washington	4.4	Virginia	3.2
New Mexico	3.4	Louisiana	3.1
Utah	3.3	Tennessee	2.6
Wyoming	2.9	Indiana	2.4
Others	9.0	Others	23.5
Total	85.0	*Total*	80.0
Use	Quantity *bgd*	Use	Quantity *bgd*
Munic. & rural	5	Munic. & rural	12
Industrial	3*	Industrial	65†
Irrigation	77	Irrigation	3
Total	85	*Total*	80

* Plus approximately 1 bgd brackish water.
† Plus approximately 12 bgd brackish water.

An isolated statistic, in itself, does not mean much, but it is of incidental interest that the present per capita use of water throughout the nation for all purposes except hydroelectric power runs to the fabulous figure of more than 1,100 gpd!

This figure is equivalent to about 1,700 tons per year. Of this amount, one-third disappears through evapotranspiration, supporting the growth of food and fibers. Most of the remainder does not evaporate, but returns, more or less polluted, to streams and rivers, often having passed through the nation's homes and through more than 250,000 mines, factories, and steam power plants (*1*).

All else consumed by man is outweighed by water, yet it is scarcely discernible in the family budget. In our billion-dollar-per-day economy, the total national water bill probably does not exceed $3 billion a year. The city dweller's share is about $500 million and agriculture's probably $200 million; the remainder is borne by industry. The total investment in all types of water facility projects is roughly $40 billion (*1*), or a little more than our outlay for railways ($32 billion) and almost twice that for power, which stands at $25 billion but is advancing at the rate of $3 billion a year.

Looking back over the years, one can recall when a couple of buckets a day per person in a household did very well. Sanitary facilities, washing machines, air conditioning, and a score of other personal conveniences, including the luxury of doing without a water meter and working on an unlimited nonpenalty supply, have changed all that. Water has now become an essential factor in our way of life and exerts a powerful influence upon industrial and population trends.

The combination of a fairly high average rainfall and the superb natural arteries of large inland rivers and lakes in many regions of the continent has deluded the majority of us into believing that water is one resource about which we in America need have no concern. Consequently, a water problem is a brand new experience to many. In terms of maintaining our existing standard of living the question of adequacy of water supply is bound to be one of

TABLE 2

Agricultural Resources Required to Produce 1,000,000 Automobiles

Item	Quantity	Resources Used	Purpose
Water	15 bil gal		manufacturing processes only
Soybean oil	2,000,000 lb	10,000 acres of soybeans	enamel
Mohair	350,000 lb	87,500 goats	upholstery fabric
Lard	1,000,000 lb	20,000 hogs	lubrication, oxalic acid
Leather	1,500,000 sq ft	30,000 head of cattle	glue, upholstery
Wool	3,200,000 lb	800,000 sheep	upholstery, carpets, gaskets
Molasses	2.5 mil gal	12,500 acres of sugar cane	antifreeze, solvents
Linseed oil	2,400,000 lb	17,500 acres of flax	paint, oil, soap, glycerin
Corn	500,000 bu	11,280 acres of corn	rubber substitute, alcohol
Cotton	89,000,000 lb	558,000 acres of cotton	upholstery, brake linings, gears

increasing importance. We can—indeed, we will be forced to—adopt better practices in the development and use of the water resources available; but, even then, water, like crops, forest products, and mineral resources, will limit population and industrial expansion.

The United States is not running out of water, but the seventeen western states, as a whole, are using about 70 per cent of all the water they may expect to develop at reasonable cost. Arizona's water use already exceeds the dependable supply available within its borders. Texas is talking of importing water from the Mississippi, and Oklahoma plans a 450-mile water supply and irrigation canal linking the abundant watersheds of eastern Oklahoma with the drier central and western sections. The largest water-using states and the types of demand are shown in Table 1. From this tabulation it follows that the heaviest single withdrawal of water is for irrigation. The seventeen western states use nearly as much for irrigation as the 31 eastern states use for all purposes.

Agricultural Base

The relationship between agriculture and a highly industrialized society such as that of the United States is frequently overlooked. At first thought, for instance, an automobile plant seems an operation quite remote from that of a farm. Statistics should generally be given with the same reluctance as they are apt to be read, but those which follow bear so vividly on the industry-farm relationship that we may well devote a moment to their consideration. It has been computed that to produce a ton of steel requires 65,000 gal of water and to turn out a million automobiles requires the various resources listed in Table 2. These figures become even more impressive when it is pointed out that we must multiply them six or seven times in order to turn out the number of new cars required per year on this continent.

In all that we do, we are forced to count on the great asset of our agricultural base, namely, our forests and soils and water resources. These "renewable" resources provide approximately one-half of our entire national economy, measured in goods consumed, or in their transport, processing, financing, and marketing. We are apt to think of ourselves as a mechanized society wherein metals and minerals play a predominant role, but the industrial complex will gradually weaken unless

we not only maintain but substantially improve our agricultural practices. Although the overall picture of our forests indicates that replacement growth shows promise of catching up with annual drain, the fact still remains that we are using up saw timber at a rate 40 per cent greater than its annual growth. We have destroyed one-fifth of the original area of our crop lands and are continuing to injure a considerable portion of the rest by improper agricultural methods. We are beginning to feel the pinch of water shortages in various parts of the continent. All in all, we are not as yet conserving these vital resources sufficiently to insure the welfare of coming generations.

American population growth is largely a result of the remarkable advances in sanitation and medical care that have occurred concurrently with economic expansion and the development of transportation. The wholly unexpected change in our population expectancy has actually resulted, however, from three unforeseen circumstances: [1] somewhat larger immigration than foreseen; [2] a continuing decline in the death rate; and [3] the predominating factor of a sharp and sustained upsurge in the birth rate. It is sufficient to take the now generally accepted opinion that our population will reach a figure of at least 190,000,000 by the year 1975, 30,000,000 more people than we have today. This prospect poses a host of problems, such as the physical functioning of ever larger cities, the increased costs of various forms of social welfare, and the added load upon our educational system, which, in many respects, is incapable of meeting present demands. The essential question—the one first to consider—will still remain: can our farm lands produce sufficient food for this substantial increase in our numbers? The food-producing capacity of our country is so great that it is illogical to anticipate a food crisis, at least within the period of which we are now thinking. Further, the diet standard of the American people as a whole is relatively so high that moderate downward adjustments could be made without physical ill effect.

At present crop lands, plus land devoted to livestock used for food supplies, aggregates 464,000,000 acres. The latest computations prepared by the US Dept. of Agriculture, submitted in testimony before Congress in 1952, indicate that the amount of land that will be needed to provide food at present diet levels for our anticipated population in the year 1975, including provision for our present export surplus, adds up to the formidable figure of 577,000,000 acres—113,000,000 more than is now in use. The day is still to come when we are sufficiently alert to the fact that the protection of our agricultural base is the first need of our physical future. The necessary change in our outlook on the country's food supply will finally do away with the fantasy that "America can feed the world." Let us never forget, however, that the problem of water will always dominate the entire natural-resource picture.

Water Resources Conservation and Development

The water development recommendations included in President Eisenhower's 1954 "state of the Union" message are seen as presenting a potential program second in size only to highway construction. A problem which is coming in for more attention than ever before is the effect of industrial wastes on some of our important rivers.

Americans are fortunately devoting an increasing amount of thought and action to problems connected with stream pollution. In days gone by, when the economy was largely agricultural, industry was given every encouragement possible by communities to locate or expand, even though they faced rising stream pollution loads. The states, as well as the nation, stood idly by while free air and free water were exploited. Particularly in the East, "once in and waste" was accepted practice in using large quantities of water for processing, cooling, or cleaning out industrial debris. Many rivers are still used as "open sewers," and mines are allowed to contaminate large volumes of water which would otherwise be available for domestic use.

How costly this lack of foresight can be has been the subject of much discussion at symposiums during a recent annual meeting of the American Assn. for the Advancement of Science, held at Boston, Mass. Several speakers stressed the need for gathering facts before giving the green light to any far-reaching schemes for water use, whether public or industrial. Some idea of the costs involved were given by Francis A. Pitkin, chairman of the Interstate Commission on the Delaware River Basin. Discussing "Correction of a Fluviatile Delinquent, the Schuylkill River," he said that recent rehabilitation measures to remove silt and culm (coal debris) dumped in the river by coal mine operators over a period of 130 years have cost Pennsylvania $35,000,000, while the federal government has spent $10,000,000. Mine operators, to stay in business under new laws, have had to invest $6,000,000 to keep their silt and culm out of the Schuylkill. To clean up all the nation's rivers in 10 years would cost somewhere between $9 and $12 billion, according to one authoritative source (*2*).

Despite the provocative title of Pitkin's paper, there was no doubt that most of the symposium participants realized it is not America's rivers that are delinquent, but Americans themselves. The responsibility for restoring the Schuylkill to some semblance of its original cleanliness has been accepted by state and industry, but those concerned with water supply matters would be derelict in their duty if they did not strive on a nationwide scale to prevent a continuance of such problems. Not only is dredging expensive and water treatment complicated as well as costly (where water is needed for municipal or industrial uses), but there are intangibles such as lowered property values, health hazards, added flood dangers, loss of recreational facilities, and destruction of aesthetic values also to be considered.

An important recommendation in President Eisenhower's message was that the nation take steps to insure an adequate supply of water. In this connection, it is estimated that, apart from the $9–$12 billion which would be required to make the country's streams reasonably free of pollution, an additional $12–$15 billion is necessary for expansion and conservation. It is gratifying to observe that industrialists are among the first to recognize this urgency. Charles M. White, president of Republic Steel Corp., emphasized it in a recent article (*3*) and quoted an announcement of General Motors Corp. as stating that "Water is our most important raw material."

The nation's average 30 in. of rainfall annually is much more than adequate for our needs, but unfortunately, too much of it (8 in.) is lost through wasteful runoff. Therefore, a major

portion of our water problem lies in the field of conservation. From the standpoint of self-interest, as well as of national interest, industry should do everything it can to relieve the water crisis promptly.

Why the water shortages? Demands have exceeded existing sources of supply, particularly in growing communities and those with new industries. Treatment, storage, and distribution systems were not planned ahead and are now inadequate. In about one-third of the instances, drought has been a factor. In the majority, the shortages were due to lack of foresight and development; the big need, however, is conservation, and metering is a must.

The sea has been suggested as a possible source of fresh water. Although the desalting of ocean water has been made possible for the sailor by several clever gadgets using chemicals or sunshine, a large-scale solution to this problem is as elusive as it has ever been. Recently the Conservation Foundation published a book (*4*) that reviews the physics and economics of two-score methods of desalting the ocean. The group picked as a goal the design of a plant that would produce 1 bgd, or about the amount New York City uses. Of all the methods considered, from distillation to biological growth techniques to electrical devices, the researchers found only one—the ion-selective membrane—which could produce this quantity at a price of no more than 30 cents per 1,000 gal. The group pointed out that large users of water now pay about 0.5 cents per 1,000 gal and that any price greater than 6 cents puts manufactured water out of reach of farmers. (New York City's water costs 20 cents per 1,000 gal, delivered.) To arrive at the 30-cent figure, the scientists made many assumptions which they readily admit are probably too modest. For example, the cost of power was put at 0.5 cents per kilowatt-hour. Power—even atomic power—at such a price will probably not be available in arid regions. Furthermore, 1,000 ppm dissolved solids was allowed. (The US Dept. of Agriculture calls this grade permissible; New York's water contains less than 50 ppm.) With distillation methods, using conventional fuels, the cost is 70 cents per 1,000 gal, and distillation is second best to the selective membrane device. The authors dismiss solar energy for water purification entirely. They calculate that, even with the maximum efficiency thus far obtained with any known device, 300 sq miles of apparatus would be needed to supply 1 bgd, at a cost of $8 billion.

The membrane method suggested by the group utilizes a series of plastic sheets. These act as sieves either to the positively charged sodium particles or the negatively charged chloride particles, but not to both at once. The sheets are arranged in alternate layers, with a negatively electrified plate at one end and a positive plate at the other. As the particles are attracted to the plates of opposite electric charge, they move through one sieve but not through the other. They become trapped between the sieves and can be pumped away, leaving fresh water behind.

The US Dept. of the Interior is encouraged over prospects for developing a process for economical conversion of saline into fresh water. It is spending $400,000 a year on research in its $2,000,000 program.

Although industrial uses, as a rule, are not highly consumptive, there is now a trend toward reducing the amount of water for such purposes, particularly by industries located in

the semiarid states of the West and Southwest. A new steam-electric plant at Amherst, Tex., uses just over 1 gal of water per kilowatt-hour, as compared with the 80 gal used by conventional older plants. This trend is due to grow and is an intelligent step which enlightened leadership must take.

A scientific research program, conducted by meteorologists and cloud physicists and aimed at determining how much the fertilization of dry regions throughout the nation can be advanced by stimulation of rainfall was recently announced. The study of clouds as a possible untapped water resource will be made jointly in the arid Southwest by the University of Chicago and the University of Arizona. To facilitate the program, a new Institute of Atmospheric Physics has been formed at Tucson, Ariz. The expenses of the institute will be defrayed partly from state funds and partly from private sources, including chiefly the Sloan Foundation.

The scientists engaged in this work have been occupied in research on clouds and thunderstorms for several years and are carrying out fundamental laboratory studies and field measurements in cooperation with the Air Force. Knowing from balloon measurements the temperatures at the various levels in which the clouds lie, the meteorologist can determine whether subfreezing conditions play a part in the formation of the rain or the snow that melts into rain as it falls. Present rain-making techniques normally require subfreezing temperatures in the upper parts of the clouds. A special radar set to scan the clouds will be installed on one of the mountain peaks above the valley floor around Tucson. Cameras will photograph the echoes received on the radarscope from clouds that are forming rain. It is planned that the new institute will study other problems of the atmosphere, such as the possibility of the use of the energy in the bright sunshine of Arizona, but clouds and rain possibilities will be the main interest at first.

Artificial nucleation may have other useful potentialities, such as increasing snowpack in mountainous areas, deterring and weakening rainstorms (thereby reducing soil erosion), inhibiting hail, breaking up hurricanes, and aiding aircraft operation.

These activities give hope of solving the problem of providing an adequate water supply—a vital part of the larger problem of conserving and developing the natural resources upon which the well-being of the nation depends.

Acknowledgment

This paper is partially based on information contained in published reports from federal government sources (*2, 5*), some of which was summarized in a recent article by Bello (*1*). Osborn's writings on natural-resources problems (*6*) have also proved of great assistance.

References

1. Bello, Francis. How Are We Fixed for Water? *Fortune*, p. 120 (Mar. 1954).
2. President's Materials Policy Commission. *Resources for Freedom.* US Govt. Printing Office, Washington, D.C. (1952).
3. White, C. M. Will Water Shortages Flash the Stop Sign on Industry? *Clevelander* (Jan. 1954).
4. Ellis, C. B., et. al. *Fresh Water From the Ocean.* Ronald Press Co., New York (1954).
5. MacKichan, K. A. Estimated Use of Water in the United States—1950. *USGS Circ.*, No. 115 (1951).
6. Osborn, Fairfield. *The Limits of the Earth.* Little, Brown & Co., Boston, Mass. (1953).

Sea Water for Cation Exchanger Regeneration at Ventura

By James M. Montgomery

A paper presented on May 25, 1954, at the Annual Conference, Seattle, Wash., by James M. Montgomery, Cons. Engr., Pasadena, Calif.

THE use of sea water for the regeneration of cation-exchange materials is not new. Papers (*1, 2*) have been published describing a municipal plant located in Sarasota, Fla., and an industrial plant in Fernandina, Fla., which soften water by ion exchange, using sea water as the regenerant. A number of such plants have been reported in Cuba. On the Pacific Coast, an installation using this process has been in operation at the Union Oil Co. Wilmington refinery since 1941. The plant, as originally built, used a carbonaceous ion-exchange material, but the enlarged plant uses a nonphenolic, styrene-base resin.

Most of the early installations employed synthetic siliceous gel type ion exchangers. Such material has an exchange capacity of about 10,000 grains (gr) per cubic foot when salt (NaCl) is used as the regenerant. With sea water in place of salt, the exchange capacity is only about 6,000 gr per cubic foot. Therefore, considerably larger installations were required for sea water regeneration than were necessary for salt.

Synthetic siliceous gel exchanger is relatively low in price per cubic foot, but low initial cost is its only advantage as improved materials are now available. Some of the characteristics that have made it obsolete, at least for municipal and large industrial installations, are: relatively low exchange capacity; relatively short life; susceptibility to contamination with iron; relatively high salt consumption; narrow permissible range of pH values for the water being softened; and gradual loss of silica to the water being treated.

Within the past few years a number of synthetic organic ion-exchange materials, with greatly improved operating characteristics, have been developed. A nonphenolic, styrene-base resinous exchanger has proved particularly well suited for municipal and industrial water softening plants. This material, under different trade names * but with similar operating characteristics, is produced by a number of manufacturers.

At the 200-mgd Frank E. Weymouth Water Softening and Filtration Plant of the Metropolitan Water Dist. of Southern California, there are 24 upflow ion-exchange softening units, making it by far the largest such installation in the world. The ion-exchange

* Such as Chempro C-20 (Chemical Process Co., Redwood City, Calif.), Dowex 50 (Dow Chemical Co., Midland, Mich.), Nalco HCR (National Aluminate Co., Chicago), Permutit Q (Permutit Co., New York), and Amberlite IR-120 (Rohm & Haas Co., Philadelphia).

material now used in all of these units is of the nonphenolic, styrene-base type. Some of this material has been in use for 5 years and has softened more than 4.5 mil gal per cubic foot. The material has been purchased piecemeal, under rigid specifications, with each contract going to the lowest qualified bidder. The trade names, number of softening units, and quantities used are as follows: Nalco HCR, 7 units, 11,025 cu ft; Amberlite IR-120, 8 units, 13,920 cu ft; and Chempro C-20, 9 units, 14,835 cu ft. Salt from a deposit in the Mojave Desert is used as the regenerant.

TABLE 1

Exchanger Characteristics

Characteristic	Synthetic Siliceous Exchanger	Organic Styrene-Base Exchanger
Overall exchange capacity—*gr/cu ft*	10,000±	23,000±
Salt consumption per hardness removed —*lb/kgr**	0.35–0.5	0.25
Permissible pH range for water being softened	7.2–8.3	6.0− to 9.5+
Life—*mil gal/cu ft*	1–1½	5+

* Kilograins.

The characteristics which make styrene-base ion exchanger particularly desirable for industrial and municipal use are: extremely long life; high exchange capacity; low salt consumption; chemical stability; relatively low price per unit of exchange capacity; and resistance to heat. Table 1 compares the principal characteristics of synthetic siliceous and organic, nonphenolic, styrene-base exchangers using NaCl for regeneration.

Its high exchange capacity, low salt consumption, and long life make styrene-base exchange material particularly well suited for use when sea water is available for regeneration. Synthetic siliceous exchanger with sea water as the regenerant has an overall exchange capacity of 6,000 ± gr per cubic foot and requires 15 ± gal of sea water per cubic foot, compared with 13,000 gr and 25 ± gal for organic styrene-base exchanger.

Ventura Problem

Like most other cities in the country, and particularly in Southern California, Ventura, Calif., has had, and continues to have, its water problems. The principal source of supply has always been the Ventura River. When available, the surface flow has been used; otherwise, the underflow has been pumped from the gravels behind a submerged dam.

In 1939 the city constructed a lime–soda ash water softening and filtration plant located on the Ventura River about 5 miles north of its mouth. The sludge produced by the lime-soda process was run into drying beds for disposal, because discharge of the sludge into the river was forbidden by government agencies. Near the plant site, ground is at a premium, owing to the narrow river valley and the proximity of valuable citrus groves and oil fields. By 1945 practically all available land was covered with sludge, which was being produced at a rate of approximately 3,000 cu yd per year.

Studies were made to determine the best means of permanent sludge disposal. In the East, lime sludge is sometimes used to improve acid soil, but, in the semiarid West, the soil is already too alkaline. No large quarries or gravel pits where the sludge might be placed existed nearby. The

California Fish and Game Commission even disliked the idea of ocean disposal. In the course of these investigations, it was found that the sludge problem could be eliminated if the plant were converted to the cation-exchange process and that the saving in chemical cost would more than pay for the expense of conversion.

Before the city council could act, a much greater problem developed. All of Southern California was faced with a prolonged drought, and Ventura had to seek an additional water supply. During the drought period the flow of the Ventura River dropped to an all-time low of less than 1 mgd and the city's summer requirement was about 5 mgd. A geologist was employed by the city council to locate a new source of supply. From electrical logs and drilling data of all of the oil wells sunk at Ventura, he was able to locate water wells that proved to be excellent producers. The well water, however, was even harder than Ventura River water. Furthermore, the wells are located near the beach, about 7 miles from the Ventura Avenue treatment plant. Using the same plant to soften both water supplies was out of the question. Consequently, the city council authorized the construction of a new ion-exchange softening plant for the new well supply and the conversion of the existing plant to the ion-exchange process. Both plants were to employ sea water for regeneration with standby facilities for the use of purchased salt in emergencies.

As the wells would be operated only when needed, principally in the summer, it was decided that the cost of the well supply softening plant (at Seaford Avenue) would be kept at a minimum and the existing plant (at Ventura Avenue) would be in permanent operation.

Ventura Avenue Plant Sea Water Intake

Where sea water is used for the regeneration of ion-exchange material, the usual practice is to pump the water from some tidal estuary, chlorinate it, and filter it, through pressure filters. At Ventura, however, there is no tidal estuary—nothing but continuous beach exposed to the action of the surf. The only break is the mouth of the Ventura River, where a bar forms during periods of low flow in the stream. It is always comfortable to be able to follow precedent, but none could be found for getting sea water from the surf at reasonable cost. As the plants were widely separated, two intakes had to be provided.

It was decided to use the beach sand itself as a filter medium. It was recognized that some dilution with fresh water would be inevitable, but it was felt that the rate of pumping of sea water would be too great for the dilution to be significant. Operating results proved that fresh water dilution, in itself, did not affect the results. The use of radial water collectors with collecting pipes in the sand below the surf was considered but rejected because the cost was thought too high. Two radically different types of intake construction were finally designed for the two plants.

At the site selected for the Ventura Avenue plant intake, the entire beach is underlain with stones ranging in size from small gravel to boulders. This structure is, of course, very stable and resistant to surf action under all conditions. The intake consists of an open-top concrete box, 4 ft wide, 3 ft

deep, and 30 ft long (inside dimensions), with four 4-in. perforated copper collection pipes on the bottom and with graded sand and gravel above the pipes. Working around the clock, a hole was dug on the beach about 22 ft from the mean low tide line, and the material from the excavation was bulldozed continuously into the surf to form a protective barrier against the action of the breakers. The previously assembled intake box was placed in the excavation, with the long dimension parallel to the beach and the top of the box at el −6. The collection header was connected to the suction piping, a 5-ft thick layer of rock backfill was placed over the box, and the natural beach material was replaced, partly by bulldozer and partly by the action of the surf.

Automatically controlled jet type pumps, located in a shore well, lift the sea water which filters through the intake system into a storage tank. Two booster pumps, with capacities of 175 and 300 gpm, housed in a combined pumping and chlorination building, deliver the chlorinated sea water through an 8-in. mortar-lined and -coated steel pipeline, approximately 5 miles long, to the Ventura Avenue plant. The water elevation in the plant is 216 ft.

The sea water intake for the Ventura Avenue plant does an excellent job of filtration, producing a clear, sparkling brine. After 3 years of operation it is felt that the design is sound but that the unit is uncomfortably small and should have been installed about 2 ft deeper. At extreme low tide the delivery is inadequate, but when the tide is higher the capacity is ample. The formation in which the intake is located is tight, and the rate of filtration per square foot of beach area is low. So far, by taking advantage of the tides and keeping the 200,000-gal filtered sea water storage tank as nearly filled as possible, the plant has been operated without serious interruption and with the use of very little purchased salt. If the filter unit had been built longer, placed deeper, and located closer to mean low tide line, however, it would be possible to pump all of the sea water needed at any stage of the tide.

Seaward Avenue Plant Sea Water Intake

The beach for a mile or more in either direction from the Seaward Avenue plant is deep sand and subject to erosion during winter storms. Occasionally the beach has been almost completely removed by violent winter wave action and then restored during the following summer season. The construction of an intake at this location was recognized as hazardous. Two alternative plans were considered. One was to construct a radial collector with the concrete well located safely back from any historic wave erosion and with perforated collector pipes extending through the beach sand under the surf. The other plan was to install a wellpoint collector system deep in the beach sand near the mean low tide line; connect the wellpoints to a header piped to a pumping station; and deliver the filtered brine to the plant by means of a self-priming centrifugal pump. The decision to adopt the second plan was made by the city council, acting upon the advice of the engineers and in the face of some misgivings on the part of a civil engineer member of the council.

The choice of wellpoints was based on the difference in cost of the alterna-

tives. The quoted price of the radial collector was $40,000, as against $4,500 for the wellpoint system. Both of these figures were for the collection system alone and did not include pumps or piping. During the 10 years immediately preceding construction, the beach had been very stable. It was felt that the wellpoint system could be replaced several times, using purchased salt during the repair period, and the costs would still be less than for the radial collector. Also, it was believed that costs should be kept as low as possible because, as has been mentioned, the Seaward Avenue plant was to be considered a standby facility, for use during the summer when flow in the Ventura River was low.

The wellpoints gave excellent results initially, but, after a few months of operation, production gradually diminished. It was found that the small amount of fresh water which diluted the sea water contained both iron and hydrogen sulfide. The latter was in sufficient quantity to have destroyed many of the copper wellpoint screens. The iron was in solution, but, at low tide, the wellpoints dried up the beach and drew in air, which precipitated the iron. The precipitated iron made a sticky mass around the wellpoints, which, after a time, greatly reduced the intake capacity.

Numerous efforts were made to improve the effectiveness of the wellpoints. As a last resort, the screens were removed from the points; they were spaced farther apart and reset deeper, in 6-ft, perforated, asbestos-cement pipe wells packed with gravel inside and concrete sand outside. The revamped wellpoint system worked very satisfactorily throughout the summer and into the winter of 1952–53. Then a violent storm washed away the sand and gravel from around the points, and, when the beach rebuilt itself during calm weather, the unscreened wellpoints let the sand pass into the pipeline and pump. The installation remained in place but was useless.

The city council and the water department management felt that something more dependable than wellpoints was required. In December 1953 bids were received on a horizontal perforated-pipe intake system protected by steel sheet piling. The bids were considered too high, however, and were rejected. Immediately thereafter the city advertised for bids on a radial collector and has recently let a contract for this type of installation at a price of $45,000. The installation is expected to be completed in August 1954. In the meantime the plant must use purchased salt.

Ventura Avenue Softening Plant

The Ventura Avenue softening plant, as originally built for lime–soda ash softening, had a capacity of 4.5 mgd, based on a filtration rate of 2 gpm per square foot. It was designed for series operation, with primary flocculation, settling, and carbonation; secondary flocculation, settling, and carbonation; and filtration. The detention times were 45 min each for primary and secondary flocculation and 3 hr each for primary and secondary settling. The overflow rate in each of the settling basins was 800 gpd per square foot.

When the plant was redesigned for ion-exchange treatment, the flocculation and settling basins were set up for parallel operation. The three filter units, with a total area of 1,500 sq ft, were refitted with new troughs, rearranged valving, and brining facilities.

The filters were converted to gravity type ion-exchange softeners by placing 3,200 cu ft of nuclear sulfonic acid, nonphenolic, organic cation exchanger in the units, divided approximately equally among the three. The capacity of the plant is now 6.5 mgd.

This plant is unique in that no provision has been made for bypassing hard water for dilution. Instead, all of the water is passed through the softeners, and the units are overrun in order to produce the desired quantity of dilution water. This is made possible by the fact that the clear well is exceptionally large, holding approximately 2 days' storage. With this large volume of storage capacity, practically perfect blending of the hard and soft water is achieved. Also, overrunning of the units increases the efficiency of the operation by utilizing all of the exchange capacity of the resin.

TABLE 2

Ventura Avenue Plant Data, 1952–53

Item	Quantity
Number of softening units	3
Volume of exchanger per unit—*cu ft*	1,067
Theoretical exchange capacity per unit —*kgr**	13,871
Hardness removed—*gr/gal*	19
Total water softened—*mil gal*	1,367
Total rinse water and other plant uses —*mil gal*	93
Total sea water pumped—*mil gal*	74
Volume of sea water per quantity of water softened—*gal/mil gal*	54,000
Energy cost for pumping sea water —$	2,725
Energy cost per quantity softened— $/*mil gal*	2

* Kilograins; the figure is based on an exchange capacity of 13,000 gr per cubic foot.

The hardness of the unsoftened water averages approximately 475 ppm, which is reduced to approximately 150 ppm. Table 2 gives operational data for the year 1952–53.

At present-day Southern California prices of $21 per ton for hydrated lime and $39 per ton for soda ash, the chemical cost of softening by the lime–soda ash process would be approximately $55 per million gallons. The cost of softening using purchased salt at $11 per ton and assuming a salt consumption of 0.25 lb per 1,000 gr of hardness removed would be $26 per million gallons. The cost of pumping sea water in 1952–53 was $2 per million gallons of water softened. At current prices, the saving due to the use of ion exchange with sea water regeneration instead of lime and soda ash is approximately $73,000 per year.

The cost of the plant conversion was $468,000, including the sea water intake and pumping plant ($63,500), the pipelines for sea water and spent brine ($224,400), the plant reconstruction ($131,600), and the ion-exchange material ($48,500). Assuming an interest rate of 3 per cent and a plant life of 30 years, the $73,000 saving would justify an expenditure of $73,000 × 19.6 (present-worth factor), or $1,430,800.

From the time that it was completed and placed in operation, the Ventura Avenue plant has operated satisfactorily except for the previously mentioned difficulties experienced with the sea water intake.

Seaward Avenue Softening Plant

The Seaward Avenue plant was built to soften the water from three new wells located near the ocean front. At the time, September 1949, the three wells were thought to be for supplemental use only, and, therefore, the investment in the plant was kept as

low as possible. The capacity of the plant is 5 mgd and the total construction cost, including sea water intake, sea water supply and waste piping, and pumping facilities, was $140,000.

The low cost was made possible by the use of the inexpensive wellpoint intake system, which proved to be unsatisfactory, and the use of upflow units, which permitted high-rate operation and made rate-of-flow controllers unnecessary. The filtered sea water storage tank was built above the three softening units.

The wells were completed and placed in operation some time before the plant was designed. The total hardness, from many analyses, was found to be approximately 550 ppm, and the iron content in all of the wells was less than 0.3 ppm. The results of these analyses, plus a generous safety factor, were used in designing the plant. Even though the iron content was low, facilities were provided to add sodium hexametaphosphate to the raw water in order to hold the iron in solution.

Water from the wells is delivered to a 30-ft diameter steel tank, 24 ft high, which provides the head necessary to force the water through the upflow softening units. It was recognized that free carbon dioxide in the water, if released in these units, would upset the operation. It was felt, however, that the free carbon dioxide might be released in the head tank, and, although provision was made for the future installation of aerators, the original construction did not include them. This omission proved to be a mistake. Enough carbon dioxide was released in the softening units to carry the exchanger over the troughs and into the distribution system. Aeration facilities were then installed, at a cost of approximately $6,000, and trouble from this source ceased.

After the plant had been operating satisfactorily for about 6 months, the character of the well water changed quite suddenly. The total hardness increased to approximately 650 ppm, and the iron content rose to more than 1 ppm in each of the wells. At the same time that trouble began to develop in the sea water intake, the length of runs between regenerations became shorter. Iron began to accumulate in the exchange units, apparently coming both from the well water itself and from the sea water diluted with iron-bearing fresh water. After a time it was necessary to clean the beds with hydrochloric acid. One of the great advantages of the resinous exchange material is the fact that it can be operated on an acid cycle. Iron can be removed by acid treatment and the original exchange capacity restored. It will probably be necessary to treat the exchanger with acid once or twice a year as a routine procedure.

It is anticipated that, when the new sea water intake is completed, ample low-iron brine will be available and the plant will again operate as it did initially. At present it can be operated only by using purchased salt. The operation of both plants has, however, demonstrated the economy of ion-exchange softening using sea water for regeneration. Owing to the lower pumping lift, the cost of sea water at the Seaward Avenue plant is actually less than at the Ventura Avenue plant.

Whenever water softening is contemplated within economical distance of tide water, the ion-exchange process with sea water regeneration should be considered. The cost of purchased salt

must be weighed against the cost of building and operating sea water facilities. The possible savings through the use of ion exchanger with sea water regeneration, instead of lime–soda ash or ion exchanger with regeneration by purchased salt, warrant the expenditure of a considerable sum of money.

References

1. Richheimer, C. E. Sarasota's Automatic Sea Water Regeneration Zeolite Water Softening Plant. *Jour. AWWA*, **29**:1712 (Nov. 1937).
2. Nordell, Eskel & Richheimer, C. E. Rayonier Fernandina Water Treatment Plant Sea Water–regenerated Zeolite Units. *Paper Trade J.*, **110**:47 (Mar. 21, 1940).

Discussion

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In addition to the installations mentioned by the author, sea water regeneration is used at a number of plants in Mexico, South America, and Japan. A few plants, both industrial and municipal, employ natural brines.

Commercial-Salt Regeneration

Cation-exchange water softeners are usually regenerated with purchased salt, averaging better than 98 per cent in purity. The dosages used vary from 0.25 to 0.5 lb per kilograin of hardness removed, and the salt is applied as a diluted brine, usually ranging from 10 to 15 per cent in strength.

No attempt is made to convert the cation exchanger entirely to the sodium state, for such a complete transformation would require very large dosages of salt and would be too high in operating cost. Thus, even a freshly regenerated cation exchanger still contains a certain proportion of calcium and magnesium, in inverse ratio to the regeneration salt dosage.

Sea Water Regeneration

Sea water contains 2.7 per cent sodium chloride and has a total-salt content of 3.5 per cent. Therefore, the sodium chloride in sea water constitutes only about 77 per cent of the total salts. The remaining 23 per cent consists mostly of magnesium and calcium salts, in a ratio of more than 5:1, expressed as $CaCO_3$. Although the total salinity varies somewhat in different locations, the relative proportions of the various salts are the same in all oceans.

Obviously, when a cation exchanger is regenerated with sea water, there is a greater amount of calcium and magnesium in it, in proportion to the sodium, than when the regeneration is carried out with a solution of commercial salt. Consequently the exchange capacity will generally be 40–60 per cent less with sea water than with commercial-salt regeneration. In other terms, a sea water regeneration plant will require $1\frac{2}{3}$–$2\frac{1}{2}$ times the amount of cation exchanger used in a salt regeneration plant of equivalent capacity. Although the initial cost of a sea water regeneration plant is higher than that of a plant regenerated with commercial salt, the operating costs of the former are so much smaller than those of the latter that the initial-cost difference is quickly made up. The author's comparative cost figures illustrate this point very clearly.

Other examples might also be cited. A certain municipal cation-exchange softening plant which reduces 1,100 ppm hardness to 100 ppm would have had a salt cost of $155 per million gallons if operated on purchased salt. With sea water regeneration, the cost is only $9.00 per million gallons. An industrial plant using sea water regeneration softens more than 10 mgd of 340-ppm hardness water at a cost of only $3.00 per million gallons.

Natural-Brine Regeneration

Although much rarer than sea water regeneration plants, there are in this country both municipal and industrial water softening plants that employ connate waters or natural brines for this purpose. These vary greatly in salinity, as well as in chemical composition. For instance, samples of 50 natural brines showed a total-salt content ranging from as little as one-half to more than 5½ times that of sea water.

The calcium content in most of the samples ranged from one to several times the magnesium content. If the salinity is more than 3 per cent and the chloride content (as Cl) is not less than three times the total hardness (as $CaCO_3$), and if the brine is in chemical balance and free from oil, hydrogen sulfide, barium chloride, or other harmful impurities, it can be used as a regenerant. Many natural brines will meet these specifications. Usually the alkalinity is low, but the calcium bicarbonate content and the temperature are sometimes sufficient for calcium carbonate to be precipitated on exposure to atmospheric pressure or when the water is aerated. Treatment with lime, together with filtration, will bring these brines into chemical balance. Barium chloride is an unusual constituent in such brines, but it is occasionally found. If a brine is free from sulfates, it is well to test whether barium is present.

Notable Steel Pipe Installations

By Julian Hinds

A paper presented on May 26, 1954, at the Annual Conference, Seattle, Wash., by Julian Hinds, Gen. Mgr. & Chief Engr., United Water Conservation Dist., Santa Paula, Calif.

PIPE dates back to the bamboo pole and hollow log and to the pottery and lead tubes of the Egyptians and Romans. Iron, although used to a limited extent in cast form, could not be economically employed until the development of a practical process for the manufacture of welded wrought-iron pipe early in the nineteenth century. In 1812 machinery was invented in England for welding barrels for firearms and other cylindrical articles. Three years later William Murdock, a Scot, employed old musket barrels discarded after the Napoleonic wars to make gas pipe to light some of the gloomy streets of London. In 1824 James Russell, an Englishman, invented a process for the welding of tubes, with or without a mandrel, by a combination of tilt hammer and rolling operations. The following year Cornelius Whitehouse conceived a method of manufacturing pipe by drawing long, flat strips of hot metal, known as skelp, through a die or bell, forming a whole length of pipe in one operation. Then, for the first time, man had the basis for making strong pipe rapidly and economically.

Five years after the Whitehouse invention the first furnace in the United States for making pipe was built by Morris, Tasker, and Morris in the basement of a Philadelphia shop. In 1836 this firm erected a large mill and machine shop, and in 1849 a still larger building was constructed by the company to house nine pipe-welding furnaces. Gradually other pipe mills came into being in the United States, and the services of this useful product were greatly expanded.

Steel did not begin to replace puddled wrought iron until after the development of the Bessemer process in 1855 and the open-hearth process in 1861. Even then there was some delay, as manufacturers were so engrossed in applying the new processes to rails, structural steels, and so forth, that their value for pipe making on a commercial scale was not appreciated. It remained for Thomas J. Bray, Supt., Tube Dept., Riverside Iron Works, Wheeling, W.Va., to weld the first steel pipe successfully in 1887. In the early fifties, however, pipe formed by riveting wrought-iron sheets together was used for the conveyance of water in California, and in 1868 such a line was built to supply water for San Francisco. There is some question about the date of the first large riveted steel water main laid in this country, but it is well known that the East Jersey Water Co. built a major steel water line to supply Newark, N.J., in 1891.

Steel pipe of different forms, protected by various types of coatings

where necessary, has been used in the United States since 1860 for the conveyance of water for domestic, industrial, irrigation, and other services. Many millions of feet of steel water mains have been installed in the past 60 years. During this period several types of fabricated steel pipe were used for large water mains. From about 1860 to 1930 riveted construction was used largely, especially prior to 1905, when the familiar lock-bar construction came into existence. Thereafter lock-bar pipe was used widely until the early 1930's, when the welding processes were developed extensively and welded pipe replaced both the riveted and lock-bar types.

This paper will outline some unusual and interesting steel pipe installations throughout the world, giving facts and statistics concerning some aqueduct projects, penstock installations, and others that have attained prominence owing to some unusual feature of construction or service. It should be emphasized that the instances mentioned here represent only a small portion of the total. The ones described are exceptional or conspicuous in themselves or noteworthy because of the conditions and time of installation.

Aqueducts

The construction of the aqueduct that brought the waters of the High Sierra and Owens River across 250 miles of desolate desert and rugged country, at a terminal rate of 400 cfs, to Los Angeles (*1*) set a new standard of public service for American municipalities. Up to then, 1913, no other public work at all comparable in magnitude to this aqueduct had ever been accomplished within the limits of cost ($23,000,000) and time (5 years) fixed by the engineers in their first estimate. It is not an exaggeration to say that the builders of this aqueduct established a world's record for efficiency and economy.

Among other interesting features of this aqueduct are the spectacular inverted steel siphons along its route. They are particularly notable for what was at that time an unconventional design. The thirteen siphons, with a combined length of 49,575 ft, consist of riveted steel pipe, the diameter ranging from $7\frac{1}{2}$ to 11 ft and the thickness varying from $\frac{1}{4}$ to $1\frac{1}{8}$ in. Many of these siphons are only $\frac{1}{4}$ in. thick, with diameter-thickness ratios as high as 528:1. Most of them are laid aboveground on piers and, after 40 years, are still rendering excellent service. The only difficulty that has ever been encountered is sweating at some of the riveted joints. Consequently, certain portions of $\frac{1}{4}$-in. and $\frac{5}{16}$-in. pipe were replaced in 1940 with $\frac{3}{8}$-in. welded steel pipe, which was stiff enough to resist the recurrent stresses caused by surges. The head on the siphons varies from 67 ft at Quigley to 850 ft at Jawbone. Furnished and installed, the siphons cost only approximately 4 cents per pound. Truly, they are a monument to the genius of William Mulholland, who was in charge of planning and building the aqueduct.

The Bouquet Canyon inlet-outlet steel pipeline (*2, 3*), a 1934 addition to the Los Angeles aqueduct, is also worthy of note. This line connects the main aqueduct south of Fairmont Reservoir to Bouquet Reservoir, a distance of 18,000 ft. The pipe is mostly 94 in. in diameter but reduces to 80 in. at San Francisquito Canyon, where the head is 840 ft and the plate thick-

ness is $1\frac{1}{16}$ in. Laid entirely aboveground through extremely rugged terrain, the pipe is the first major large-size steel water line of all-welded construction. It also is the first to be coated on the inside with the modern type of coal-tar enamel. It is notable in that its construction ushered in new and better design criteria for major water supply pipelines.

Colorado River Aqueduct

The Colorado River Aqueduct and distribution system, largely constructed during the 1930's, was intended to provide an ultimate capacity of 1,600 cfs for many cities and water districts in the Southern California area. The actual length of the aqueduct, from its intake on the Colorado River, about 15 miles north of Parker, Ariz., to its terminus at Lake Matthews, near Riverside, Calif., is 242 miles, making it one of the most imposing aqueducts in the world. In addition, the project involved the construction of several hundred miles of wholesale delivery lines. It was built during the depression at a tremendous saving in cost and has served as an insurance policy for the development of Southern California by guaranteeing an adequate water supply for many decades to come.

The delivery lines—one from each of the five pumping plants scattered along the eastern portion of the aqueduct and lifting the water through a total height of 1,617 ft—consist of approximately 6,000 ft of 10-ft diameter welded steel pipe. These lines were all laid aboveground and supported by ring girders. The circumferential field joints were all riveted, although the pipe itself was all welded in the shop. About 3,000 tons of plate was required for these lines, which were begun in 1936. A second unit will be built during 1954, and the third and final unit will be constructed in the future.

The Santa Ana River siphon of the Colorado River Aqueduct, near Arlington, Calif., consists of about 10 miles of all-welded steel pipe with diameters ranging from 138 to 116 in. and thicknesses from $\frac{1}{4}\frac{7}{2}$ to $\frac{3}{8}\frac{1}{2}$ in. (*4, 5*). Installed in 1936, the pipe is all buried, except at the Santa Ana River, where it is supported aboveground and across a 540-ft long steel bridge by ring girders (Fig. 1). The maximum head at the lowest point of the siphon is 500 ft, and the capacity of the line amounts to 750 cfs, roughly half of the ultimate delivery capacity of the aqueduct. The interior of the pipe was lined with spun coal-tar enamel, and the exterior was coated with $\frac{3}{4}$-in. thick mortar. The total weight of steel required for this siphon was 32,000 tons.

These two notable steel pipe installations are the most conspicuous examples of their type in this tremendous aqueduct system.

Hetch Hetchy Aqueduct

The main water supply of San Francisco, Calif., is derived from Lake Eleanor and Hetch Hetchy Reservoir in the High Sierra of Yosemite National Park and is transported through an aqueduct across the San Joaquin Valley to Crystal Springs Reservoir, near San Francisco, a total distance of about 150 miles. The ultimate capacity of this aqueduct is 400 mgd.

In order to carry water across the wide San Joaquin Valley, two welded steel pipe siphons, each $47\frac{1}{2}$ miles in length, have been constructed under a maximum head of about 500 ft. These unusual siphons consist of 56–

66-in. diameter steel pipe of $\frac{5}{16}$–$\frac{1}{2}$-in. plate thickness (*6*). There are many other major steel pipe installations in the San Francisco water system, but these siphons represent the most outstanding examples of this type of construction in the system.

East Bay District Aqueduct

The East Bay Municipal Utility Dist. Aqueduct serves Oakland, Calif., and adjacent cities on the east side of San Francisco Bay, deriving its water supply from the Mokelumne River in the High Sierra, southeast of Sacramento, Calif. The First Mokelumne Aqueduct, started in 1924, consists of 94 miles of pipe and tunnel. The route across the San Joaquin Valley required a long siphon which was constructed of 81 miles of steel pipe 65 in. in diameter. This was the first major all shop-welded steel water line ever built. The field joints were riveted. This notable steel line had served the district for about 20 years when it reached its ultimate capacity. A second giant steel line of similar construction, except that the new line is all welded, has been built parallel to the old line (*7, 8*). The new line has a diameter of 68 in. and has brought the capacity of the aqueduct up to 200 mgd. The portion of the pipe laid aboveground is supported by steel saddles of unusual design. At some future date a third line will increase the capacity of this system to its ultimate limit.

Other Aqueducts

It will be observed that the four examples of aqueducts presented thus far are all located in California. It must not be inferred, however, that no important aqueducts exist anywhere else in the world. A number of other famous aqueducts bringing vital water supplies through large-size steel pipelines to their respective communities will be listed briefly:

1891, 1896 — Newark, N.J. — approximately 65 miles of 36–60-in. pipe.

1893 — Rochester, N.Y. — approximately 26 miles of 36–38-in. pipe.

1895 — Pittsburgh, Pa. — approximately 20 miles of 60-in. pipe.

1895 — Portland, Ore. — Bull Run No. 1 Aqueduct, approximately 25 miles of 33–42-in. pipe, deactivated in 1953 owing to obsolescence because of small size. The pipe was still in good condition after 58 years of service.

1897 — Paterson, N.J. — approximately 8 miles of 42-in. pipe.

1899 — Seattle, Wash. — approximately 6 miles of 42-in. pipe. An additional 12 miles of 42-in. pipe was installed in 1903.

1902—Jersey City, N.J.—approximately 17 miles of 72-in. pipe.

1902 — Australia—world's longest steel pipe aqueduct (Coolgardie), 351 miles of 30-in. lock-bar pipe.

1905–07 — Springfield, Mass.—approximately 24 miles of 42–54-in. pipe.

1906 — Brooklyn, N.Y. — approximately 8 miles of 72-in. pipe.

1906 — Philadelphia—approximately 26 miles of 36–48-in. pipe.

1910 — New York City — Catskill Aqueduct, approximately 8 miles of 66–135-in. pipe.

1910 — Portland, Ore. — approximately 25 miles of 44–52-in. pipe.

1914 — Victoria, B.C. — approximately 11 miles of 36-in. pipe.

1920–22—Detroit—approximately 40 miles of 40-in. pipe.

1924 — Portland, Ore. — approximately 25 miles of 50-in. lock-bar pipe. In 1952 a similar line of welded steel pipe, 25 miles long, was installed.

1927 — Medford, Ore. — approximately 32 miles of 20-in. and 25-in. pipe.

1928 — Everett, Wash. — approximately 22 miles of 30-in. welded steel pipe.

1929–31 — Vancouver, B.C. — approximately 36 miles of 20–60-in. pipe.

1930—San Diego, Calif.—approximately 16 miles of 36-in. and 40-in. welded steel pipe.

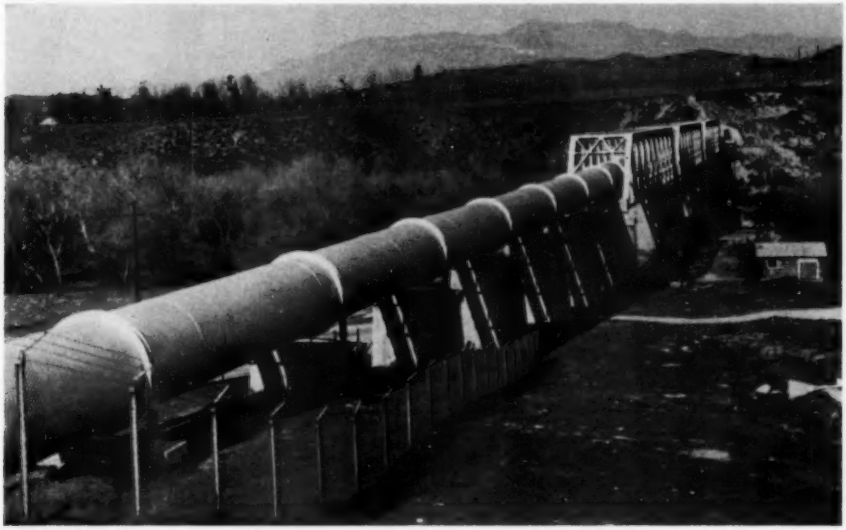

Fig. 1. Santa Ana River Crossing

The 116-in. diameter all-welded steel pipe has a plate thickness of $\frac{31}{32}$ in. and operates under a maximum head of 500 ft.

1930 — Philadelphia — steel water supply conduit installed under unusual conditions (*9*). This line consists of 20,000 ft of 93-in. diameter riveted steel pipe, $\frac{9}{16}$ in. thick, followed by 14,000 ft of 72-in. diameter pipe, $\frac{1}{2}$ in. thick. Although this conduit is relatively short, compared to other large supply lines for big cities, it was laid under a greater variety of conditions than many lines that are much longer. The route of this conduit extended through 8,600 ft of city property, 3,500 ft of private property, 2,600 ft of narrow city streets, and 20,000 ft of wider streets, where a section of double trolley tracks was in constant use and where subsurface structures of water, gas, sewer, telephone, and electric utilities had to be maintained. Also, two sizable creek crossings had to be made. This work required considerable planning by the water engineers and presented numerous problems. The line was installed with dispatch, however, and Philadelphia obtained a new water supply of 250 mgd from this project.

1930 — North Jersey Dist. Water Supply Commission, N.J.—Wanaque Aqueduct (*10*), 164,150 ft of 74-in. lock-bar pipe ($\frac{7}{16}$ and $\frac{1}{2}$ in. thick), a

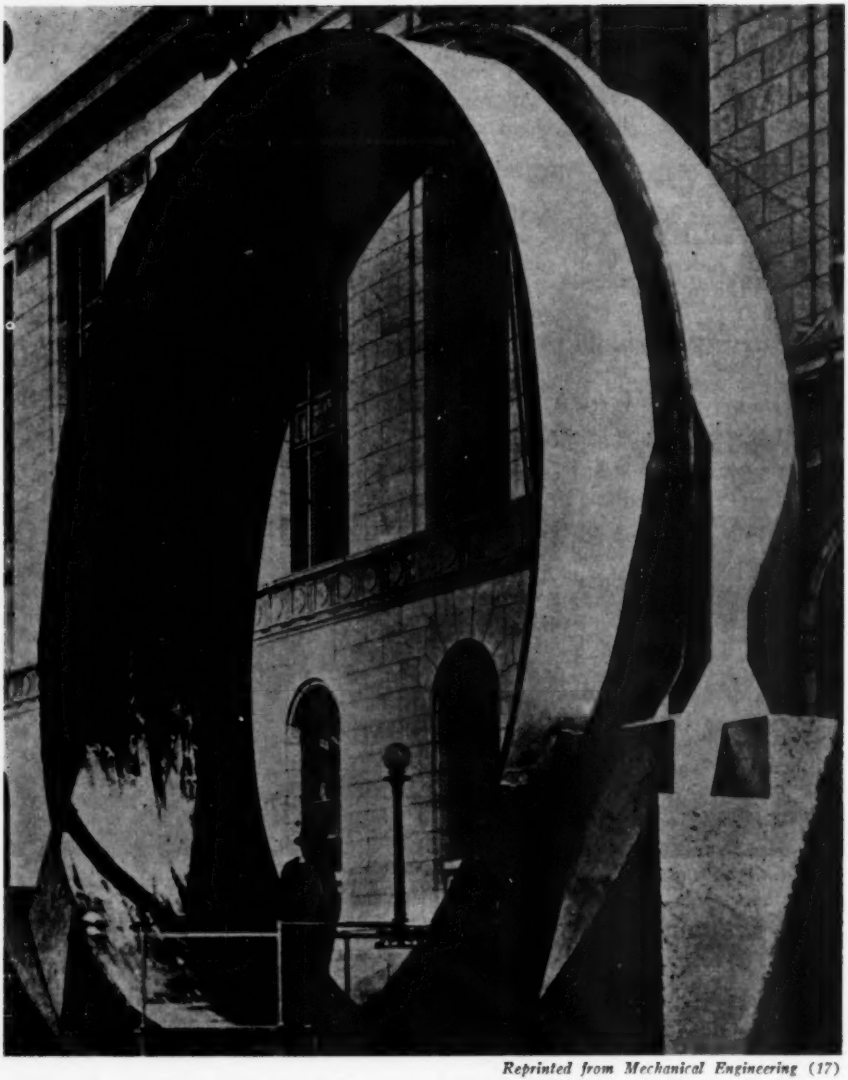

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Fig. 2. Hoover Dam Penstock Section

This full-size replica of a section of the main penstock is 30 ft in diameter.

total of 35,000 tons of steel plate. The aqueduct supplies 100 mgd for eight communities in northern New Jersey. The greater part of this work involved cut and cover construction, and 14 miles of the project was laid as twin lines. The field work offered some unusual difficulties, especially at the

eleven major stream crossings encountered. In 1951 the Wanaque Reservoir yield was increased by the construction of 25,000 ft of 72-in. pipe from the Ramapo River.

1931—Hackensack, N.J., Water Co.—approximately 6 miles of 52-in. lockbar pipe.

1932—Tamaqua, Pa. (Panther Valley Water Co.)—approximately 10 miles of 30-in. welded steel pipe (*11*).

1933—Washington, D.C.—approximately 6½ miles of 48-in. welded steel pipe (*12*).

1933 — Seattle, Wash. — approximately 6 miles of 78-in. pipe.

1934 — Pasadena, Calif. — approximately 18½ miles of 36-in. welded steel pipe (*13*).

1935 — Fort Smith, Ark.—approximately 23 miles of 27-in. welded steel pipe (*14*).

1937 — Everett, Wash. — approximately 20 miles of 36–52-in. welded steel pipe.

1938—Birmingham, Ala.—approximately 44 miles of 42–60-in. welded steel pipe (*15*).

1949—Sydney, Australia—approximately 15 miles of 84-in. pipe laid aboveground. The total weight of steel pipe used in the project was 20,000 tons.

1951—Adelaide, Australia—approximately 36 miles of 42–56-in. pipe, weighing 38,000 tons.

1952 — Medford, Ore. — approximately 30½ miles of 30-in. welded steel pipe (*16*).

Penstocks

Some of the most interesting and spectacular steel pipe installations ever built anywhere in the world can be seen in various penstocks constructed on steep mountain slopes in conjunction with the delivery of water to hydroelectric power plants. The development of hydroelectric power in the western United States furnishes some of the most romantic pages of its colorful history. It is replete with examples of initiative, ingenuity, and daring which have been the marvel of the engineering world. The first major hydroelectric installation on the Pacific Coast was built by the Willamette Falls Electric Co. at Oregon City, Ore., in 1889. Since that time many hundreds of other plants have been built, a few of which will be mentioned briefly.

Hoover Dam

Hoover Dam, located on the Colorado River in southern Nevada, contains the largest and most notable of all penstocks ever built (*17*). The main penstock (Fig. 2), 30 ft in diameter, consists of about 5,600 ft of welded steel pipe, varying in thickness from $1\frac{3}{4}$ to $2\frac{7}{8}$ in. Further along, this penstock is reduced to 25 ft in diameter; in this section, there is about 2,200 ft of pipe, varying in thickness from $1\frac{13}{16}$ to $2\frac{3}{8}$ in. The branches that run directly into the power plants are 13 ft in diameter and consist of about 4,600 ft of pipe, $1–1\frac{5}{16}$ in. thick. The total weight of steel used in this penstock system amounted to approximately 45,000 tons. The maximum head is approximately 500 ft. All of the penstocks are installed in tunnels and are connected by cold-pinned butt strap field joints. The pipe was fabricated in a special shop erected at the site, and the successful automatic shop welding of the thick plates involved extensive research.

The ultimate installed capacity proposed for this plant is 1,835,000 hp. This great project stands as a tribute to its designers and builders. The extraordinary size of these penstocks, combined with the difficulty of the conditions involved, presented tremendous

design problems to the engineers of the US Bureau of Reclamation, but they were all solved successfully.

Grand Coulee Dam

Grand Coulee Dam, on the Columbia River in eastern Washington, contains the largest-capacity hydroelectric power plant in the world. The ultimate installed capacity will amount to 3,012,000 hp. The main penstocks serving this project are not as large as those at Hoover Dam, but they are spectacular indeed. The eighteen welded steel penstocks, encased in the dam, are 18 ft in diameter and have a total length of 5,267 ft and a plate thickness of $\frac{3}{4}$–$1\frac{1}{2}$ in. (Fig. 3). In addition, this project includes 672 ft of 14-ft diameter steel pipe, $\frac{1}{2}$ in. thick, serving as pump inlet lines, and 955 ft of 72-in. diameter station service penstocks with $\frac{3}{8}$–$\frac{9}{16}$-in. plate thicknesses. These penstocks required 10 miles of welding work. Furthermore, the Grand Coulee pumping plant contains twelve plate steel discharge pipes running aboveground from the pumps to the discharge outlet structure. They consist of a total of 9,373 ft of 12-ft diameter welded steel pipe with thicknesses of $\frac{7}{16}$–1 in. The maximum lift is 363 ft, and each of the twelve lines is designed to carry 1,600 cfs (*18*). The Grand Coulee Dam project is of enormous magnitude, and the 15,000 tons of steel pipe within it is making a signal contribution to the operation of this great system.

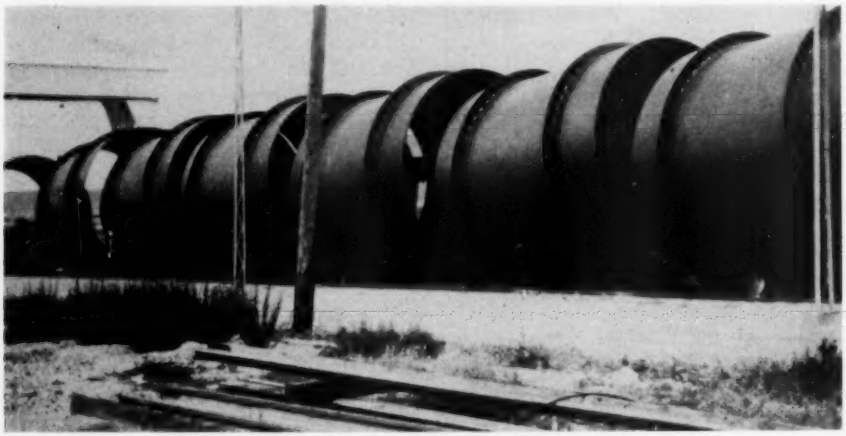

Fig. 3. Grand Coulee Dam Penstock Sections

Eighteen welded steel penstocks, 18 ft in diameter, are encased in the dam.

Other Reclamation Bureau Dams

Shasta Dam in northern California is another large Reclamation Bureau project, in which the main-unit penstocks consist of five 15-ft diameter all-welded steel pipes having a total length of 4,500 ft and varying in thickness from $\frac{3}{4}$ to $2\frac{1}{2}$ in. The approximate weight of the steel used was 8,000 tons (*19*).

Parker Dam on the Colorado River near Parker, Ariz., provides storage of

water for the intake of the aqueduct of the Metropolitan Water Dist. of Southern California. It has a power plant which is served by four 22-ft diameter steel penstocks having an aggregate length of 700 ft and a thickness ranging from $\frac{9}{32}$ to $\frac{15}{16}$ in. (*20*).

Davis Dam is also located on the Colorado River, about 67 miles downstream from Hoover Dam. Power is developed there by five generators, and each turbine is served by a 22-ft diameter steel penstock varying in length from 175 to 305 ft and in plate thickness from $\frac{3}{4}$ to 1 in. This installation is unusual in that it is the largest-size pipe installed by the US Bureau of Reclamation with flexible deflection and expansion joints. These joints are designed to permit both vertical and horizontal movements produced in the line by settlement of the foundations and by temperature changes (*21*).

Engineer Corps Dams

The US Army Corps of Engineers has built a number of noteworthy penstocks in conjunction with power plants located adjacent to its dams. Fort Peck Dam in Montana has a hydroelectric plant with an unusually compact penstock and powerhouse system. Three large, interconnected steel plate surge tanks are located in structural combinations with the powerhouse. There are four tunnels, one of which is steel lined for 3,118 ft and serves as a pressure tunnel for power purposes. The liner is a riveted steel penstock, 24 ft 8 in. in diameter, with a plate thickness of 1–1¼ in., involving nearly 8,000 tons of steel (*22*).

At Garrison Dam, near Bismarck, N.D., the welded steel penstocks for the tunnels consist of 4,800 ft (three 1,600-ft runs) of 24-ft diameter steel pipe ranging in thickness from $\frac{7}{8}$ to 1¼ in. The total weight involved, including ring girder supports, is 10,000 tons. A unique feature of these penstocks, besides their large size, is the adoption of articulated mechanical couplings for the field joint connections. It is believed that these couplings are the largest of their kind ever built.

Los Angeles Power Plants

Los Angeles operates a series of power plants along the Owens River Aqueduct. Two of these projects have steel penstock installations of interest. San Francisquito Plant No. 2, about 15 miles north of Saugus, Calif., is notable in two respects. In 1928, when a severe flood rushed down the canyon, the original powerhouse was completely washed away in the surge of water that rolled by this point to a depth of 125 ft. At that time there were two riveted steel penstocks, 1,400 ft long and 71–84 in. in diameter, located on the side of the canyon wall, leading directly into the power plant at the bottom. It was found that the two penstocks had withstood the flood without any damage, even though they were laid aboveground on concrete saddles. Later, in 1932, after the new power plant had been built, a third penstock was laid —the first rivetless, all electric-welded steel penstock constructed in the United States. That installation marked an advance in the art of hydroelectric generation in this country, and the Los Angeles power engineers deserve great credit for pioneering it.

Los Angeles has recently completed its new 112,500-kw hydroelectric project at Owens River Gorge, 15 miles north of Bishop, Calif. (*23*). This development is unique in that the three power plants involved are interconnected for remote control and are iden-

tical in design, each containing one 37,500-kva generator and one 51,200-hp Francis turbine, operating under a static head of 790 ft. Each power plant is served by welded steel penstocks varying in size from 106-in. diameter and $\frac{3}{8}$-in. thickness at the upper end to 92-in. diameter and $1\frac{1}{16}$-in. thickness at the lower end.

The terrain at Plants No. 1 and No. 2 is extremely steep and rugged, while, at Plant No. 3, it is not so severe. The general topography of the whole Owens River Gorge project is such, however, as to permit identical design of all three plants to utilize a full static head of 2,375 ft over an 18-mile stretch of the river. The total length of all of the penstocks is approximately 9,000 ft, and about 7,000 tons of high-strength steel plate has been used.

Electric Company Plants

The Pacific Gas and Electric Co. of San Francisco supplies electric power for central California. It has constructed and now operates numerous unusual hydroelectric plants and penstock systems all along the central portion of the High Sierra. Pit 5 project, completed in 1944 with a peak output of 160,000 kva (*24*), is the largest privately owned hydroelectric plant in California and the fifty-second such plant built by the company. Located on the Pit River in northern California, it is designed for simplicity and economy. A total of 3,300 cfs of water is conveyed from the diversion tunnels down to the power plant by means of four welded steel penstocks, each 1,400 ft long. The diameter and thickness vary, respectively, from 102 and $\frac{3}{8}$ in. at the top to 90 and $1\frac{1}{4}$ in. at the bottom. The maximum static head is 630 ft. This installation also includes the first all-welded scroll cases for turbines under such a high head. The project introduced many other new features for hydro plants and is one of the most interesting ever built in California.

The Electra Hydroelectric Power Plant, on the Mokelumne River, northeast of Sacramento, Calif., is noteworthy because of its high head (1,268 ft). The steel penstock leading to the turbines is 114 in. in diameter and $\frac{7}{16}$ in. in thickness at the top and 90 in. in diameter and $1\frac{3}{4}$ in. in thickness at the bottom, running down a slope of 70 deg for a distance of 3,400 ft. All of the pipe sections are 30 ft long and shop electric welded. In the field, all connections were of the riveted butt strap type to avoid the possibility of developing welding stresses that could not be relieved.

The Pacific Gas and Electric Co. has many other power plants of interest on the Pit, Mokelumne (*25*), and Feather rivers, but one of the most notable installations owned by this company is the Balch plant on the Kings River. It is important not because of its size but because of its high operating head. At the time of its construction, in 1927, it held the record as having the highest head of any plant in America—2,336 ft. Another unique feature of this plant is the location of the powerhouse on the opposite side of the river from its penstock pressure line. (The Bucks Creek power plant, built in 1928, has two penstocks, 36–54-in. in diameter, under 2,561-ft. head.)

The Southern California Edison Co. also has constructed a number of interesting hydroelectric plants throughout the High Sierra, principally on its Big Creek system. The Big Creek hydroelectric system, in the mountains east

of Fresno, Calif., is the backbone of the Edison hydro power supply for the southern portion of California. It consists of six major power plants. Big Creek No. 1 and No. 2, built in 1911, have penstocks under heads of 2,100 and 1,800 ft, respectively. The two steel penstocks serving the first two units of these plants were purchased from Germany.

The first penstock of Big Creek No. 8 was constructed in 1921. Made of riveted steel, it is 2,670 ft long, 72–96 in. in diameter, and $\frac{3}{8}$–$1\frac{1}{8}$ in. thick; it operates under a maximum head of 700 ft. The second unit, built in 1929, has a 2,700-ft long penstock of 84–120-in. pipe using $\frac{7}{16}$–$\frac{9}{16}$-in. thick plate.

In 1928 the highest-head power plant in the Edison system was built at Big Creek No. 2A. The maximum head is 2,418 ft, and the penstock line is 6,678 ft long, with diameters ranging from 108 in. at the top to 66 in. at the bottom. It consists of three different types of steel pipe—riveted, banded, and forged and seamless.

Big Creek No. 3, constructed in 1923 and 1948, has four parallel steel penstocks, 54–90 in. in diameter and $\frac{7}{16}$–$1\frac{3}{4}$ in. thick, operating under a head of about 800 ft (Fig. 4).

Finally, in 1951, Big Creek No. 4 was built on the San Joaquin River. The all-welded steel penstock consists of pipes 15–17 ft in diameter and operates under a head of about 400 ft, requiring plate thicknesses of $\frac{7}{8}$–$1\frac{5}{8}$ in.

Altogether, the Big Creek system produces approximately 500,000 kw and is truly a unique power project. More kilowatt-hours of electricity per unit of water are generated at Big Creek than at any other hydroelectric development in the world, and the total drop of 6,000 ft through the various power plants makes the water the hardest working on earth.

Foreign Plants

In addition to the major penstocks cited above, there are numerous other noteworthy installations throughout the world. A few of the most unusual of these will be mentioned here. In 1948–49 the British Columbia Electric Co. Bridge River plant (*26*) installed three parallel welded steel penstocks, each 2,100 ft long, consisting of 75-in. diameter pipe under a maximum head of 1,350 ft. The 40-ft pipe sections are connected by mechanical flexible type couplings, which provide for expansion and contraction at each field joint. These couplings are entirely bolted and thus obviate the need for field riveting or welding.

The Alcan–British Columbia hydroelectric project, constructed in central British Columbia for the Aluminum Co. of Canada, contains a unique penstock installation (*27*). This system is entirely underground and must withstand a maximum head of approximately 2,600 ft. Two 11-ft diameter steel penstocks are carried down through a tunnel, having about a 45-deg slope, for a distance of 4,466 ft. Each penstock then branches into two 93-in. diameter pipes, and each of these splits into 66-in. diameter branches to the turbines. The plate thickness of these penstocks varies from $\frac{9}{16}$ to $2\frac{1}{2}$ in. The large power plant for this project is also underground.

Switzerland is a country rich in natural water power resources. In connection with its many power plants, some noteworthy penstock installations have been built. The Rempen plant has double penstocks, each about 1,500 ft long and 83–95 in. in diameter, sup-

ported by ring girders spaced 74 ft apart, center to center. The maximum static head is 900 ft. The Dixence plant, built in 1934, has a penstock 18,000 ft long with a 39–56-in. diameter. The total available static head is 5,750 ft, and the pipe required 15,000 tons of plate. The upper portion is welded, the lower banded. The Innertkirchen plant has a plate-lined shaft of large proportions. The inclined shaft is 6,300 ft long and is lined with a penstock 96–102 in. in diameter, which has a maximum plate thickness of 2 in. at the bottom. The lower end branches off into five pipes to the turbines. The Lucendro plant has a 1,500-psi static-pressure penstock consisting of a single line, 1,400 ft long, of 58-in. diameter, followed by two lines 4,800 ft long,

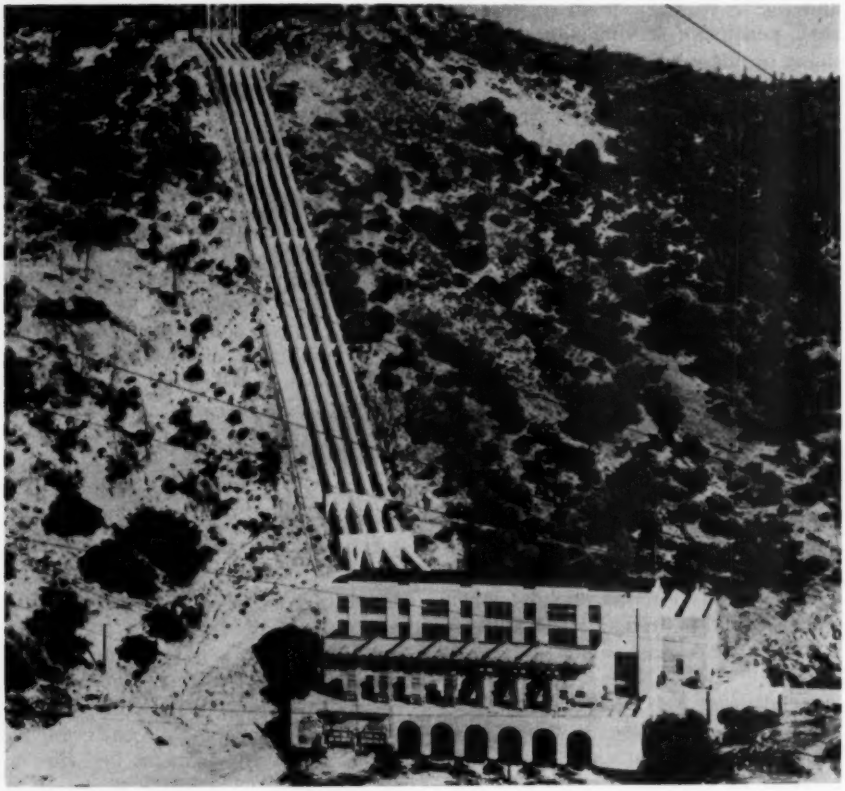

Fig. 4. Southern California Edison Company Plant

The four penstocks of Big Creek No. 3 power plant operate under a head of approximately 800 ft.

each with diameters ranging from 35 to 37 in. and a maximum thickness of 2.35 in. at the bottom.

Ring Girder Construction

Some of the most notable installations of steel pipe ever constructed are long-span, self-supporting pipe structures built aboveground with the aid of ring girders (*28*). This type of construction was given impetus in the United States about 1930, when a civil engineer named Herman Schorer developed a theory for the design of large steel pipelines supported and held in circular shape by full ring girders spaced at relatively long distances. This method was first employed in Sweden, and experience has shown that these longer spans (as compared with the customary saddle supports) are entirely feasible and result in considerable saving in cost. The ring girders are stiff, disk-shaped members that prevent distortion of the pipe at the supports.

The Shoshone River siphon (*29*) near Cody, Wyo., is the most unusual of all ring girder pipelines constructed to date, because it has the longest unsupported span between girders of any similar structure in the world. The central span across the canyon has a clear length of 150 ft. The diameter of the steel pipe is 123 in., and the plate thickness at the center of the main span is 1 in. This pipe has a maximum head of 155 ft and was built with a camber equal to the computed deflection needed to make the pipe level when full of water. Actual measurements made when the pipe was fully loaded indicated that the central span was horizontal within $\frac{1}{16}$ in. This notable structure was designed and built by the US Bureau of Reclamation as a part of the Shoshone irrigation project.

Over the Missouri River, near Toston, Mont., there is an 84-in. diameter steel pipeline of $\frac{3}{8}$-in. plate thickness, supported by ring girders, with two central spans of 126 ft each and two end spans of 98 ft each. The central spans are the second longest unsupported sections of ring girder construction known at the present time. This installation also was built by the US Bureau of Reclamation. Two other ring girder installations having spans of 100 ft or more are located over the Platte River, at Denver, Colo. (two 105-ft spans of 78-in. pipe with a $\frac{3}{8}$-in. plate thickness) and over Willow Creek at the Southern California Edison Co. Big Creek No. 4 hydroelectric plant in central California (several 100-ft spans of 180-in. pipe $\frac{5}{8}$ in. thick).

There are innumerable other ring girder type installations throughout the world having spans of 40–100 ft, but special mention will be made here of only three of them. In 1935, the Maricopa County Municipal Water Conservation Dist., near Phoenix, Ariz., built three steel pipe flumes across ravines (*30*). The 120-in. welded steel pipe, only $\frac{1}{4}$ in. thick, is supported by ring girders on steel bents spaced 60 ft apart, center to center (Fig. 5). When this installation was being constructed a number of persons watching its erection predicted it would not remain in place. It is still giving good service, however, after 19 years of use.

The Soledad siphon, located on the Los Angeles Aqueduct (31), experienced a cloudburst flow of water in its

river bed during 1944, which caused the washing away of four piers from under the riveted steel siphon pipe 10 ft in diameter and ½ in. thick. These piers were spaced 23 ft apart, and, when the washout occurred, the steel pipe siphon was left hanging for a distance of 115 ft. Even though the pipe was full of water, it remained in place with a maximum deflection of only 3½ in. under the long unsupported span. in Provo Canyon, Utah, built in 1948, replaced an old 2¾-mile long wooden power flume in 91 days with a welded steel pipe 102 in. in diameter and $\frac{3}{16}$ in. in plate thickness, laid aboveground with ring girder supports 48 ft apart. The design of this pipeline was based on the theorem of least work, and the diameter-thickness ratio amounted to 544:1. This unusual installation is further evidence of the desirability, adaptability, and economy of ring girder construction for large steel pipelines laid aboveground.

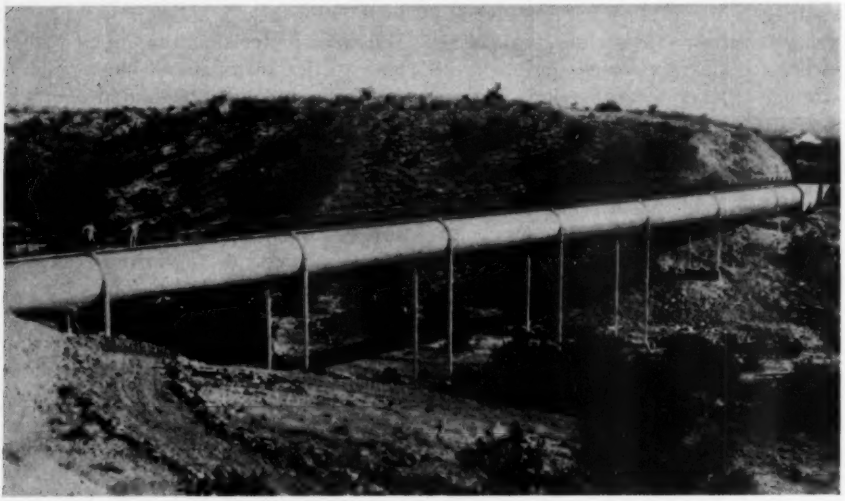

Fig. 5. Maricopa Water Conservation District Installation

Three such pipe flumes, crossing ravines near Phoenix, Ariz., are supported by ring girders on steel bents spaced 60 ft apart, center to center.

The accident proved that the pipe could stand longer spans than were used originally, and the engineers of the Los Angeles water system designed and constructed ring girder and pier supports 70 ft apart. This occurrence indicates the practical value of ring girder construction for large-size steel pipelines.

The Olmsted hydroelectric plant of the Utah Power and Light Co. (*32*),

Gas and Oil Transmission Lines

During the past 10 years great strides have been made in transporting gas and petroleum products on a large scale through long, cross-country welded steel pipelines under high pressure. One of the first of these

lines, in which the "expanded" type of pipe was used, was built in 1947, when the Southern California Gas Co. installed 214 miles of 30-in. pipe, $\frac{9}{32}$–$\frac{3}{8}$ in. thick, on its natural-gas line between Blythe and Los Angeles, Calif. (*33*). Expanded steel pipe, as used for this service, is high-strength pipe having a minimum yield strength of more than 52,000 psi; it is fabricated by customary methods, except for the operation of cold working. The most common method of cold working is to make the cylinders somewhat undersize and then expand them, usually by hydraulic pressure against machined dies of the ordered diameter. This process has several advantages: [1] the stretching or "cold working" of the steel materially increases the transverse yield strength and, to a limited degree, the tensile strength, thus permitting the use of thinner-wall pipe for a given pressure, with corresponding savings in weight; [2] the expansion of the pipe into a truly cylindrical die results in uniform roundness, size, and straightness; [3] the stretching of the pipe fully tests the strength of the welded seam at the yield strength of the parent plate.

Since the installation of the gas line mentioned above, many thousands of miles of similar lines have been constructed throughout the world. The Trans-Arabian Pipeline Co. has installed an oil line from the Persian Gulf to the Mediterranean Sea (*34*), consisting of about 1,000 miles of 30- and 31-in. expanded welded steel pipe, involving 219,000 tons of plate. The two different diameters were adopted so as to permit economy in nesting the pipe sections for overseas shipment. The Transcontinental Gas Pipeline Co. constructed a mammoth line from Texas to New York, which consisted of 1,600 miles of 30-in. pipe and required 427,000 tons of plate. The Iraq Petroleum Co., in Iraq, installed about 500 miles of 30- and 32-in. steel pipe, involving 164,000 tons of plate. The El Paso Natural Gas Co. laid 865 miles of 30-in. pipe between Texas and California, which required 216,000 tons of plate. The Pacific Gas and Electric Co. has installed approximately 1,000 miles of 34-in. high-pressure gas pipe in two lines between Topock, Ariz., and San Francisco. These are commonly known as the "Super Inch" lines because they used the largest-size pipe ever installed for gas transportation service. These giant lines required about 400,000 tons of plate. Numerous other instances could be cited (*35*).

Suspension Pipe Bridges

Of the many examples of unusual installations of steel pipe suspended over canyons or rivers, three will be mentioned here. The Ogden River Canyon in Utah (*36*) presents an interesting type of suspension pipe bridge. A 31-in. diameter, $\frac{1}{4}$-in. thick steel pipe carrying irrigation water is suspended across the canyon on a 360-ft long catenary bridge. It was designed and constructed by the US Bureau of Reclamation.

The Colorado River Pipe Bridge near Blythe, Calif., illustrates a new and unusual method of carrying large-diameter steel gas lines over a wide river or canyon (Fig. 6). A 30-in. welded steel pipeline under high pressure is supported on a suspension bridge having a clear span of 1,040 ft. A similar installation was made near Benson, Ariz., where a 30-in. pipe has an aerial suspension span of 1,020 ft.

Goleta, Calif., is the site of a novel method of suspending welded steel pipe across a series of canyons. The most notable of these installations is a 16-in. pipe that is carried across a ravine for a distance of 420 ft as a catenary. The pipe is merely anchored to the bank at both ends and forms a single span across the canyon.

Submerged Pipelines

There are numerous interesting examples of steel pipelines installed under river or sea water. During 1944 the British navy laid twenty 3-in. lines under the English Channel to supply 1 mgd of gasoline to the Allied armies in France (*37*). This vast cross-channel engineering feat, called "Operation Pluto," guaranteed uninterrupted delivery of gasoline across the channel irrespective of weather conditions or enemy attack.

San Francisco adopted an unusual design for underwater pipe in 1935 for its second bay crossing of the Hetch Hetchy system (*38*). The crossing consists of two 2,800-ft long steel pipelines, 54 in. in diameter and $\frac{3}{4}$ in. thick, encased in 6 in. of concrete and laid in sections 120 ft long. The completed 120-ft sections weighed 100 tons and were connected together by bolted flanges. They were laid on trestles 50 ft apart and were buried with at least 3 ft of cover. This spectacular installation was accomplished by the use of large barges and cranes.

In 1932 Minneapolis, Minn., laid a 60-in. submerged water pipeline across the Mississippi River (*39*). This crossing is about 750 ft long, and the pipe is of lock-bar construction with a thickness of $\frac{7}{16}$ in. The large-size pipe was pulled across the river and laid in a trench prepared in the river bottom. This installation greatly improved the distribution facilities of the Minneapolis water system.

A submarine oil pipeline located near Ventura, Calif., consists of 4,450 ft of 20-in. steel pipe which was laid under the Pacific Ocean in 19 hr. The longest pipeline of its type on the West Coast, it was built by the Union Oil Co. to serve as a loading station for oil tankers. Another oil installation, at Carlsbad, Calif., consists of about 4,000 ft of 20-in. steel pipe laid under the ocean in 13 hr. The outer end is under 50 ft of water. This line was built by the San Diego Gas and Electric Co. to permit oil tankers to pump oil to storage tanks on shore.

A steel pipeline from the Alberta oil fields to Sarnia, Ont., was completed in 1953. A very unusual feature of this line was the laying of two 20-in. pipes for 4 miles under the Straits of Mackinac, to a maximum depth of 243 ft, placing them among the deepest submerged pipelines in the world.

Other Noteworthy Installations

The Grand Canyon of Arizona is the site of a unique pumping plant that provides water from the canyon to the hotels and railroad facilities on the rim. This system, installed in 1932 by the Atchison, Topeka, and Santa Fe Railway Co., consists of 12,000 ft of 6-in. galvanized seamless pipe, 0.28 and 0.312 in. thick, connected by forged steel couplings with rubber gaskets. The total lift is 3,153 ft, and 170 gpm of water is pumped by two 34-stage units. The pipe extends up the canyon walls, which have an average grade of 45 per cent, including one vertical cliff 280 ft high.

In 1926 the Andes Copper Mining Co. in Chile constructed the La Ola

water pipeline, which consists of 32 miles of riveted steel pipe varying in diameter from 22 to 36 in. and in thickness from $\frac{3}{16}$ to $\frac{3}{8}$ in. The unusual features of this line included: [1] fabrication of the riveted steel pipe in the field; [2] a unique method of transportation—22,000 tons of material were carried over very rugged country by means of mule carts; [3] construction of a number of inverted siphons to operate at pressures up to 1,000 psi; and [4] rapidity of construction work and low unit costs obtained under difficult conditions. The pipeline was manufactured in the field during a period of 1 year, at a total cost of about $85 per ton; the largest single item of expense, except for the pipe material, was transportation.

During 1950 the state of California constructed a steel girder type bridge over the Hollywood Freeway at Western Avenue in Los Angeles. This bridge is 236 ft long and was designed to support two storm drains over its full length. The headroom was limited and the required carrying capacity was high. Therefore, an unusual design was developed for the storm drains. They were built of elliptical-shaped welded steel pipe, 5½ ft high, 6 ft 11 in.

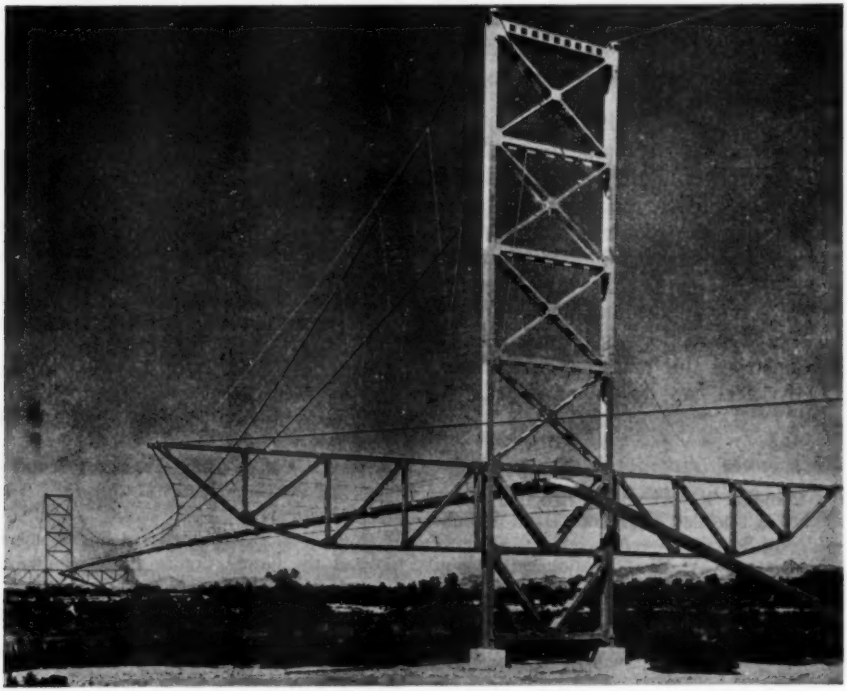

Fig. 6. Colorado River Pipe Bridge

This suspension bridge, supporting a 30-in. gas pipeline, has a clear span of 1,040 ft.

wide, and ½ in. thick. In the shop, the interior of the pipes was lined with centrifugally spun coal-tar enamel by means of specially designed equipment. The pipes were laid on each side of the bridge in cradles framed between the girders. The cradles also served as diaphragms between the girders. These unique steel storm drains can be seen from the freeway as the driver passes under the Western Avenue bridge.

The notable steel pipe installations found throughout the world attest the versatility and capability of steel pipe in fulfilling the requirements of many types of service in the water works field. This paper has also tried to indicate the important contribution of steel pipe to modern civilization and to demonstrate the truth of the slogan, "Only steel can do so many jobs so well."

References

1. Complete Report on Construction of the Los Angeles Aqueduct. Dept. of Public Service, Los Angeles (1916).
2. HURLBUT, W. W. The Bouquet Canyon Dam and Inlet-Outlet Pipe. *Jour. AWWA*, **27**:1017 (Aug. 1935).
3. VAN NORMAN, H. A. Constructing the Bouquet Canyon Pipeline. *Civ. Eng.*, **4**:306 (1934).
4. HINDS, JULIAN. Large Delivery Lines for the Colorado River Aqueduct System. *Civ. Eng.*, **8**:469 (1938).
5. Steel Pipe 11½ Feet in Diameter Welded by Improved Methods. *Eng. News-Rec.*, **118**:747 (May 20, 1937).
6. DARWIN, A. G. Hetch Hetchy San Joaquin Valley Pipeline. *Western Construction News*, p. 41 (Jan. 25, 1932).
7. TRAHERN, J. W. Aboveground Pipeline Sections of Mokelumne Aqueduct. *Jour. AWWA*, **42**:189 (Feb. 1950).
8. Water Supply Job Follows 1924 Plans. *Eng. News-Rec.*, **140**:96 (Jan. 8, 1948).
9. VAN LOAN, S. M. Building a Steel Water Supply Conduit Under Unusual Conditions. *W.W. Eng.*, **83**:1356 (1930).
10. JONES, A. A. Construction of Wanaque Aqueduct. *Pub. Wks.*, **60**:331, 379 (1929).
11. GANNETT, FARLEY. Welded Steel Pipeline of the Panther Valley Water Company. *J. Am. Welding Soc.*, **12**: 2:11 (Feb. 1933).
12. SCOTT, R. S. Washington Completes Large Pipeline. *W.W. Eng.*, **87**:596 (1934).
13. MORRIS, S. B. All-welded Steel Pipe Brings Water to Pasadena From Morris Reservoir. *Western Construction News*, **9**:310 (1934).
14. A New Source of Water Supply for Fort Smith, Ark. *Eng. News-Rec.*, **116**:240 (Feb. 13, 1936).
15. DECKER, A. C. New Industrial Water Supply System at Birmingham, Ala. *Pub. Wks.*, **67**: (Dec. 1936).
16. DUFF, R. A. & LEE, R. L. More Water for More People at Medford, Oregon. *Western Construction News*, **27**:59 (Mar. 1952).
17. DAY, C. M. & BIER, PETER. Penstocks for Boulder Dam. *Mech. Eng.*, **56**: 451 (1934).
18. MOSES, E. B. History and Development of the Grand Coulee Pumping Plant. *Mech. Eng.*, **71**:729 (1949).
19. YETTER, G. L. Welding and Testing Shasta Penstocks. *Eng. News-Rec.*, **128**:70 (Apr. 9, 1942).
20. CHRISTOFFERSON, L. G. Steel Penstock Erection at a Western Hydroelectric Project. *Civ. Eng.*, **13**:409 (1943).
21. BIER, P. J. Design, Fabrication, and Installation of 22-Foot Diameter Penstocks. *Western Construction News*, **26**:63 (Dec. 1951).
22. PENCE, A. W. Large Steel Penstock Placed in Tunnel at Fort Peck. *Eng. News-Rec.*, **118**:693 (May 13, 1937).
23. MASON, W. C. Los Angeles Builds Three Hydro Plants in Owens River Gorge. *Civ. Eng.*, **19**:24 (Dec. 1949).
24. JOLLYMAN, J. P., ET AL. Pit 5 Designed for Simplicity, Economy. *Elec. West* (May 1944).

25. P.G.&E. Breaks Records to Begin Mokelumne Power System Operation. *Western Construction News*, **23**:83 (Aug. 1948).
26. Canadian Power Plant Has 1,200-Foot Head. *Eng. News-Rec.*, **142**:60 (Feb. 17, 1949).
27. HUBER, W. G. Tunnels and Underground Penstocks. *Civ. Eng.*, **23**:50 (Feb. 1953).
28. GARRETT, G. H. Design of Long-Span Self-supporting Steel Pipe. *Jour. AWWA*, **40**:1197 (Nov. 1948).
29. BIER, P. J. Siphon Self-supporting in Long Spans. *Eng. News-Rec.*, **124**:60 (Jun. 20, 1940).
30. All-welded Irrigation Pipe. *Welding Engr.*, **20**:32 (Oct. 1935).
31. GRANT, B. S. Increased Span Length on Large Pipe Obtained by Ring Girder Suspension. *Eng. News-Rec.*, **134**:119 (May 3, 1945).
32. PURTON, T. A. Large-Diameter Steel Pipe Replaces Power Flume. *Civ. Eng.*, **19**:35 (Jul. 1949).
33. BINCKLEY, M. J. Unusual Construction Features of the 30-Inch Gas Transmission Pipeline From the Colorado River, Near Blythe, to Santa Fe Springs, California. *Calif. Oil World*, **40**:3 (Jun. 1947).
34. JOHNSON, S. P. Design Features of the Trans-Arabian Pipeline. *Mech. Eng.*, **71**:821 (1949).
35. KING, J. J. Long-Distance Natural-Gas Transmission Pipelines. *Mech. Eng.*, **73**:545 (1951).
36. SAILER, ROBERT. Suspension Bridge for Water Pipe. *Eng. News-Rec.*, **121**:75 (Jul. 21, 1938).
37. Pipelines Laid Under the English Channel. *Southwest Builder & Contractor*, p. 20 (Aug. 3, 1945).
38. Laying 100-Ton Sections of Pipe for a San Francisco Bay Crossing. *Western Construction News*, **10**:250 (Sep. 1935).
39. WILBUR, C. C. Water Line of 60-Inch Steel Pipe Pulled Across Mississippi River. *Eng. News-Rec.*, **109**:99 (Jul. 28, 1932).

Discussion

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It should be observed that, in Julian Hinds' most interesting description of steel pipelines, particularly the aqueducts and penstocks, the conditions which make an installation "notable" are almost always unusual size and operating head. The use of steel in the construction of such lines for a period of over 40 years is evidence of the faith of engineers in this material, and the satisfactory experience in the operation of the lines demonstrates the soundness of that faith. In fact, steel is the only material which time has proved to have the necessary strength and durability at a cost low enough to make such installations economical.

The writer has been connected with the design and construction of a steel water line that, although not so remarkable with respect to size, is intended for such high operating heads as to place it among the list of notable installations. This line is a unit in the program to increase the water supply for Colorado Springs, Colo.

The 30-in. steel line, when completed, will transport water by gravity from the Continental Divide near Alma, Colo., to the present limit of the city's system on the north slope of Pike's Peak, a distance of about 72 miles. Owing to the character of the terrain and the necessity of crossing from one major drainage basin into another, the entire length of the line is an inverted siphon, with operating heads exceeding 1,000 ft over much of the distance and reaching a maximum of 1,900 ft. The capacity of the line will be 18 mgd. The eastern 16.6

miles of the line were completed in 1953, along with some 14- and 16-in. lines that, with two pumping stations, enable the city to obtain a supply from the South Platte River near Lake George until the gravity line can be completed.

The welded steel pipe is lined with shop-applied coal-tar enamel and is coated with coal-tar enamel and whitewash. The manufacturers were requested to furnish their most economical 16- and 30-in. pipe for each internal working pressure classification, the thicknesses to be obtained from the formula $T = \frac{PD}{2S}$, in which P is the working pressure (psi), S is the unit stress (psi), T is the pipe wall thickness (in.), and D is the outside diameter (in.). In applying the formula, the maximum unit stress allowed in pipe design was 50 per cent of the minimum yield point of the steel. The minimum wall thickness permitted for the 16- and 30-in. pipe was 0.25 in., while that for the 14-in. pipe was 0.1875 in.

Wall thicknesses for the 30-in. pipe as furnished varied from 0.25 in. for the 240-psi classification (minimum allowable) to 0.47 in. for the 750-psi classification, the latter being based upon steel of 50,000-psi minimum yield point. Pipe was furnished in nine different classes, or working pressures, including the two limiting pressures. All 30-in. pipe was furnished in 40-ft lengths, and 14- and 16-in. pipe in double random lengths up to 40 ft.

The use of coal-tar enamel lining and coating made necessary the following construction procedure. Because of the difficulty anticipated in making repairs and inspecting the inside lining at pipe joints, an all-welded pipe, feasible when unlined, was impossible in the 14- and 16-in. sizes and was considered impracticable in the 30-in. size. Therefore, the method specified for the 30-in. size consisted of joining, by butt welding, three 40-ft lengths on the trench bank and then coupling the resulting 120-ft lengths mechanically in the trench. This procedure permitted easy access to and repair of the inside lining at welded joints and eliminated the need for pass holes in the pipe, as well as problems in ventilation that would have accompanied all-welded construction. Pipes 14 and 16 in. in diameter were connected by mechanical couplings, and welding was prohibited except for special bends or installation of fittings.

The total cost of the project, including the diversion dam, the two pumping stations, and the pipeline, was $2,176,240. About 5,200 tons of steel was required for the fabrication of the pipe.

Hanford Atomic-Energy Plant

Joint Discussion

A joint discussion presented on May 24, 1954, at the Annual Conference, Seattle, Wash.

Water Supply—*W. R. Conley*

A paper presented by W. R. Conley, Reactor Section, General Electric Co., Richland, Wash.

IN carrying on the Hanford, Wash., atomic-products operation for the Atomic Energy Commission, the General Electric Co. runs one of the world's largest water systems, supplying all industrial and sanitary needs of the manufacturing areas and the city of Richland, Wash. Industrial water is furnished by a number of plants treating a supply that comes primarily from the Columbia River but also includes some well water. Most of the water is used in the manufacturing process, with small amounts for sanitary and boiler feed purposes. Well water is used to supply Richland. Artificial recharge of the well fields with Yakima River water is practiced successfully.

Alum-Silica Coagulation

The Columbia River supply for Hanford is subjected to rapid sand filtration. Alum is used for coagulation and chlorine for disinfection. Activated silica, prepared by the reaction of sulfuric acid with sodium silicate, is employed when coagulation is weak or filtration rates are higher than normal.

The alum, chlorine, and activated silica are fed at the entrance to the treatment plant, being mixed with the raw water by mechanical means. The water flows to mechanical flocculators and then to the settling basins, where most of the floc settles out. Filtration through anthracite, sand, and gravel completes the process. The alum feed rate ranges from 3 to 15 ppm, depending on seasonal changes in the water treated. Activated silica is usually fed for about 5–6 months of the year, at rates of ½–4 ppm as needed.

Activated silica is prepared on a large scale by an automatic, continuous process in one of the manufacturing areas. The system has the advantage of low first cost, small size, and high capacity, but is more difficult to operate than a batch process. Specific gravity, methyl orange alkalinity, and pH are factors in control of the process. The silica concentration is about 1.5 per cent, and the neutralization is approximately 83 per cent. The beneficial effects of the activated silica addition on the size and settling characteristics of the floc are amazing. One disadvantage, however, is the rapid increase in head loss on the filter, as illustrated in Table 1. This condition is apparently due to the fact that the silica makes the floc so strong that it does not break up and penetrate the filter bed. On the other hand, if good

water quality is to be maintained, the floc must not be allowed to penetrate the bed to such an extent that it appears in the filter effluent. Consequently, the silica feed must be regulated to produce a floc of optimum strength which will result in high-quality water at a reasonable head loss increase.

The proper chemical treatment for a given raw-water condition is determined by laboratory coagulation tests and by chemical analyses of the plant filter effluent. Correct estimation of the necessary chemical feed of alum and activated silica, a difficult and exacting job, is necessary, if the plant is to be run with maximum efficiency and if satisfactory water is to be produced. Successful effort in this direction is rewarded by lower treatment costs and improved water quality.

TABLE 1

*Effect of Silica Feed on Filter Head Loss**

Silica Feed (SiO_2) *ppm*	Head Loss Increase *ft/hr*
0	0.08
1	0.15
2	0.25
3	0.30
4	0.38
5	0.46

* Conditions: raw-water turbidity, 25 ppm; alum feed, 15 ppm; temperature, 5°C; filtration rate, 3.8 gpm per square foot.

As in most other water treatment plants, demands at Hanford have outstripped the design capacity. By adopting modern high-rate filtration techniques, however, it has been possible to meet the increased requirements. Table 2 shows the filtration experience at various flow rates and indicates that high-rate filtration is successful at Hanford. The short runs at filter rates greater then 3 gpm are partly caused by the serious friction loss in the filter effluent piping. For example, at 6.0 gpm, the total clean filter head loss is about 5.5 ft, of which only 1.5 ft is across the filter proper, with the remaining loss resulting from the effluent piping. If the piping were enlarged to the proper size, there would be an appreciable increase in the length of filter run. Anthracite of 0.7–0.8-mm effective size has given the best overall performance of the materials tested as filter media. The only other materials tested, however, had an effective size of 0.3 and 0.4 mm.

TABLE 2

Filtration Experience at Various Flow Rates

Avg Rate* *gpm/sq ft*	Length of Run† *hr*	Backwash Water *per cent*	Time in Service *per cent*
2.5	20–50	2.9–1.2	98.3–99.3
3.0	15–40	3.2–0.9	97.8–99.2
4.5	10–20	3.2–1.8	96.8–98.3
5.0	8–14	3.6–2.1	96.0–97.7
6.0	5–10	4.8–2.4	93.7–96.8

* Including down time.
† Filter effluent turbidity was less than 0.1 ppm.

Ferric Sulfate Coagulation

Prior to the adoption of alum and activated silica, the Hanford works used ferric sulfate as a coagulant. The latter was employed successfully in the pH range 7.1–7.8, particularly in conjunction with 1–2 ppm chlorine. Coagulation with ferric sulfate has been found to be very sensitive to traces of organic compounds in the raw water. An increase of 0.2 ppm in tannic acid, for example, required a 100 per cent increase in ferric sulfate feed. On the other hand, turbidity has little effect on the coagulation characteristics of this chemical. At comparable filter rates, typical analyses showed that wa-

ter properly coagulated with ferric sulfate contained less suspended matter than alum-coagulated water (0.01 and 0.05 ppm suspended solids, respectively), but the iron content of the filtered water was higher with ferric sulfate than with alum (0.02 and 0.005 ppm Fe, respectively).

As a result of frequent iron analyses over a period of years, it has been possible for Hanford personnel to establish certain filter characteristics that are not generally known. For example, if a freshly washed filter is put on the line and iron analyses are run on the effluent at frequent intervals, the general pattern illustrated in Table 3 is observed. The filter effluent contains a maximum of 0.1 ppm iron ¼ hr after the start of a filter cycle, with the iron in the form of a very fine floc. Near the end of the filter cycle, the filter effluent again is found to contain iron in the form of a fine floc. If the raw-water quality deteriorates and the coagulant feed is not changed, the iron content of the filtrate remains constant, instead of decreasing with time as it does when the coagulant feed is properly adjusted to the prevailing raw-water conditions. An increase in coagulant feed quickly causes the filtered-water quality to return to normal. Thus, it is possible to use the iron analysis of the filtrate as a guide for regulating coagulant feed. This was done at Hanford with a precision within 0.5 ppm, except during rapidly changing water treatment conditions. Rigorous application of this technique has made possible the production of water of very high quality at less than half the previous cost.

The use of ferric sulfate at Hanford was very satisfactory from both a quality and a cost standpoint, but the proved success of alum and activated silica as a means of making high-rate filtration practical led to the abandonment of ferric sulfate in favor of alum as a coagulant.

Other Treatment

The excellent quality of the Columbia River water makes high-rate filtration more practical at Hanford than at most other locations. The turbidity of the water rarely exceeds 500 ppm even during flood stage, while the average annual value is 10 ppm or less. The temperature of the water varies from zero to 20°C during the year. One of the unusual characteristics of the river water is the uniformity of composition. The hardness, for instance, rarely departs more than 5 ppm from the annual average, and the pH, methyl orange alkalinity, sulfates, and chlorides exhibit relatively small seasonal changes. The problem of coping with algae or other forms of water life is a minor one, probably because the water is cold and contains little nitrogen or phosphorus.

TABLE 3

Variations in Iron Concentration With Time

Time After Effluent Valve Opened *hr*	Filtrate Iron Content *ppm*
¼	0.10
½	0.05
¾	0.02
1	0.01
10	0.005
20	0.005
40	0.005
42	0.02
45	0.10

Water for use as boiler feed is softened, deaerated, and treated with sodium sulfite and sodium phosphate. After about 9 years of service, the

boiler drums and tubes are still essentially free of scale and corrosion. Ion-exchange softeners are employed in most of the boiler houses, with common salt used as the regenerant chemical. Some of the softeners use an exchanger operating on the hydrogen cycle to reduce the alkalinity and total dissolved solids of the boiler feedwater. Deaeration of the water is controlled by routine dissolved-oxygen analysis of the effluent. As an additional anti-corrosion precaution, sodium sulfite is added to scavenge any oxygen that escapes the deaerator. Similarly, sodium phosphate is fed to the boiler drum to precipitate hardness that gets by the softeners.

Water for sanitary use is given a supplementary treatment with chlorine and pumped through a separate piping system. The free residual chlorine content of the water is maintained between 0.1 and 0.5 ppm, insofar as possible. Samples for bacteriological examination are taken throughout the system on a weekly schedule. The sanitary water codes of the state of Washington are generally followed.

Sodium dichromate is added as a corrosion inhibitor to filtered water used in cooling the reactors. Small amounts (a few parts per million) of dichromate have been highly successful in preventing the pitting of aluminum. Although the use of trace quantities of dichromate has been questioned by many corrosion experts, attempts to operate without it have resulted in severe pitting of aluminum. The dichromate, in the quantities used, does not have any appreciable effect on the corrosion of steel.

Within the manufacturing area, many kinds of water are being used. Pipes carrying three or four types of water at pressures that differ greatly may often be located within a few feet of each other. Consequently, accurate distribution maps and careful followups are required to prevent improper connections from being made.

Costs and Personnel

Chemical treatment costs at Hanford are relatively low, even though alum is $52 a ton and sodium silicate $37.50 a ton delivered. The high cost of chemicals results primarily from high freight charges. The nearest source of dry alum, for example, is the San Francisco area, almost 1,000 miles from Hanford. The silicate source is closer, but is still 300 miles distant. The water treatment chemical costs average about $3 per million gallons, including alum, activated silica, chlorine, and lime. Considering the very high quality of the filtered water and the high unit cost of chemicals, it is believed that an unusually economical job is being done in water treatment at Hanford.

The General Electric Co. is able to attract and hold competent operators and supervisors by a combination of good pay, good working conditions, and opportunity for advancement. As training is continuous, a large number of persons have become highly skilled in water treatment technology at Hanford. Most of the operators are high school graduates, and many seek to increase their knowledge by attending a company-run night school, where courses from the secondary-school to the postgraduate level are available at small cost.

A number of engineers and chemists are assigned to development work on water processing and utilization. Standard techniques that have been successful at other plants are evaluated at Hanford and applied if practical.

Although the security requirements of plant operation at Hanford limit the freedom with which direct outside consultation can be obtained, properly cleared outside specialists are periodically consulted on major problems. In addition, the water works literature is continually scanned for ideas.

Richland Supply

Chlorinated well water is used in the city of Richland. The well water contains more mineral matter than the Columbia River water but is obtained at a lower capital cost than would be possible if filtered surface water were employed. The wells are recharged by flooding the fields with Yakima River water. The system has been successful in meeting the needs of Richland, even though the peak demand for water is about 1,000 gpcd, a not unusual value for this arid region of southeastern Washington.

Distribution of Radioisotopes in Columbia River

Richard F. Foster and Royal E. Rostenbach

A paper presented by Richard F. Foster, Aquatic Biologist, and Royal E. Rostenbach, Chem. Engr., both of Radiological Sciences Dept., General Electric Co., Richland, Wash.

In 1945 production of plutonium was started at the Atomic Energy Commission's Hanford plant, located on the Columbia River in the south central part of Washington. The Columbia River, America's largest supply of clear, cool water, was a prime factor in the selection of the site for the water-cooled reactors. Other advantages of the area included an apparent abundance of hydroelectric power and a sparsely settled sagebrush desert which easily accommodated the 620-sq mile reservation. This paper reports some of the physical and biological factors governing and resulting from the use of the Columbia River for reactor cooling.

Columbia River

With an average flow of about 250,000 cfs and a main-stem length of 1,207 miles, the Columbia is the second largest river in the United States. Together with its tributaries, it drains an area of 259,000 sq miles. The greater part of its flow originates in the snow and ice fields on the western slopes of the Rocky Mountains, but a significant portion comes from the Cascade Range. Wide seasonal variations in flow result from rapid spring and summer thawing of snow accumulated during the winter. The peak of the freshet is reached in May or June.

Long before the discovery of the Columbia River by Robert Gray in 1792, various Indian tribes of the region depended to a considerable extent on its fish, particularly salmon, for their food supply; it is estimated that as much as 18,000,000 lb of salmon was taken annually by primitive methods. The annual catch of salmon and steelhead trout—including sports fishing—now amounts to about 27,000,000 lb and is valued at $17,000,000.

The densely forested slopes of the watershed have been the basis of one of the nation's greatest lumber industries, and much of the area is rich agricultural land. The vast new Columbia Basin irrigation project, lying immediately to the north and east of the Han-

ford project, will bring approximately 1,000,000 more acres into production.

The Columbia River is the greatest potential producer of hydroelectric power in the United States, with a projected capacity of about 34,000,000 kw. Like other large rivers, it also serves as a waterway for the transportation of produce and supplies. The construction of many huge dams for power generation, irrigation, navigation, and flood control is gradually changing the hydrography of the main stem of the Columbia and its tributaries into a series of long, quiet pools. Such a change occurred in the vicinity of Richland, Wash., in the fall of 1953, when the 61-mile reservoir behind McNary Dam was established.

The area of immediate interest covers about 120 river miles and lies generally between Priest Rapids and McNary Dam. As it passes the plutonium plants, the Columbia carries the water from a drainage area of approximately 96,000 sq miles. The flow amounts to about 80,000 cfs during the fall and winter months, when it is largely controlled by Grand Coulee Dam, but increases to approximately five times that volume during the spring freshet. In severe winters, the water temperature drops to near freezing, but, in this section, the river has not frozen over in recent times. A maximum temperature of about 19°C is reached during late summer. Throughout most of the year this section of the Columbia is remarkably clear and free from pollution, with a turbidity of less than 2 ppm. During the spring flood it becomes noticeably roiled, but turbidity rarely exceeds 500 ppm. The water is semihard, with a total-carbonate content of about 70 ppm ($CaCO_3$). The pH remains at about 8.2 throughout the year. Because of considerable turbulence in some stretches and the low organic content, the dissolved-oxygen level remains at or near saturation during the entire year.

Above the influence of McNary Reservoir, quiet pool or slough areas are the exception, and generally the current flows at a rate of about 4 mph, although it may reach 10 mph or more in rapid areas. This swift water allows little deposition, and the substrate is composed almost entirely of cobblestones. River currents have been reduced substantially in the McNary Dam impoundment, which extends approximately 16 miles above Richland.

The residential city of Richland and the construction and military community of North Richland are situated on the west bank of the Columbia River, directly above the mouth of the Yakima River, but obtain their domestic water supply from wells fed from the latter. Across the river from North Richland, a pumping station withdraws water for the irrigation of land to the southeast. Approximately 9 miles downstream from Richland, the community of Kennewick, Wash., has an infiltration gallery located at an island in the Columbia River. Directly across the river from this installation is the Pasco, Wash., water supply intake. Pasco water is treated by conventional methods of coagulation, sedimentation, filtration, and chlorination. Including other small neighboring communities, the population of the immediate area is approximately 60,000.

Substantial runs of salmon and steelhead trout pass the reactors en route to spawning grounds further upstream. A few of the large Chinook salmon remain within the Hanford reservation to deposit their eggs in

ancestral spawning grounds. Steelhead trout, together with whitefish and smallmouthed bass, provide excellent angling outside the Hanford barricades.

The magnitude of the river system and some of the important purposes which it serves have been indicated in order to permit comprehension of the size and diversity of the problems associated with the release of radioactive cooling water to the Columbia.

Radioactivity in Reactor Coolant

Water pumped from the Columbia River for cooling the nuclear reactors is first treated in the manner described by Conley (see page 629). As it flows through the reactor, certain elements present as dissolved solids become radioactive from the neutron bombardment, and other radioisotopes present as corrosion products are washed from the heat-exchange surfaces. The reactor effluent thus contains a complex mixture of radioisotopes, each contributing to the total activity. Relatively large amounts of short-lived radioisotopes are initially present but quickly decay in large retention basins. Although the radioactivity of the effluent is reduced below established levels before release to the river, appreciable amounts of such isotopes as Mn^{56}, Na^{24}, Cu^{64}, and Si^{31} are present, together with smaller amounts of longer-lived isotopes, including P^{32}, rare earths, and Cr^{51}. It should be emphasized that, under normal conditions, the radioisotopes in the effluent result from neutron bombardment of elements present in the cooling water and are not products of the splitting of uranium atoms or plutonium. The radioisotopes present in the effluent are emitters of beta and gamma radiation. The concentration of alpha emitters, such as radium and uranium, below the plant is little different from that which occurs naturally in the river upstream.

Although the tremendous dilution of the effluent resulting in the main body of the river effectively reduces the concentration of the radioisotopes, the Radiological Sciences Dept. of the General Electric Co. continually assays the radioactivity in the Columbia. Programs have been developed to evaluate the radiation hazard associated with the use of the river water for domestic and irrigation purposes, and with the eating of fish caught from the river. The US Public Health Service also carried on studies during 1951–53.

The potential effect of the effluent on valuable salmon and game fish has been investigated since July 1945, soon after the reactors began operating. Trout and young salmon have been subjected to various dilutions of the reactor effluent as a routine monitoring function; studies on the pickup, concentration, and deposition of radioisotopes present in the effluent have been carried out on various aquatic organisms, with special emphasis on food chain relationships; and field surveys have been made to determine not only the radioactivity density of the river life but also ecological relationships and balances. Laboratory studies have demonstrated that adverse effects are not encountered until the concentration of the effluent is increased to several times that normally resulting in the river. Observable effects of higher concentrations are attributable to dichromate added to the cooling water or to elevated temperatures. No effect from the small amounts of radioactivity present has been detected.

Sampling and Processing Methods

Assaying of Columbia River water for radioactivity concentration was initiated in 1944, even before the reactors began producing plutonium. Sampling of river organisms was started in 1946. At present samples are routinely collected throughout the year at selected sites between Priest Rapids and McNary Dam. Water samples are likewise taken from the municipal supplies of Pasco and Kennewick. Samples are collected regularly downstream to the mouth of the river. Although not affected by radioactivity in the Columbia River, water samples are also routinely collected from the Yakima and Snake rivers, which discharge into McNary Reservoir, and from the water supplies of Richland and other communities of southeastern Washington.

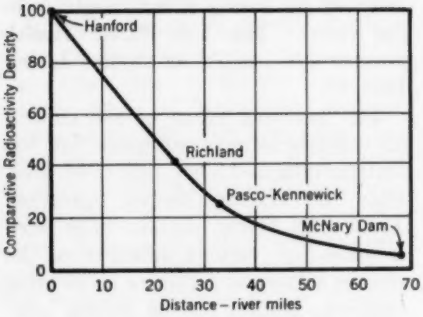

Fig. 1. Diminishing Radioactivity With Distance Downstream

Radioactivity reaches a maximum a few miles below the reactors and then gradually diminishes.

Water samples are obtained routinely by simply dipping up the required quantity, which varies from about a pint near the reactors to about 1 gal in the vicinity of McNary Dam. Special surveys for careful mapping of the distribution pattern utilize a 30-ft diesel-powered boat equipped with a pump and weighted suction hose for drawing water from any desired depth. Large fish are collected with gill nets, set lines, and occasionally rod and reel. Small fish from the shoreline areas are captured with hand seines. Plankton is collected with standard silk bolting cloth nets, either anchored in the current near shore or suspended in tanks carried by the boat. As the plankton consists mostly of small diatoms, a substantial portion passes through the meshes of standard plankton nets, and high-speed centrifuges are necessary to concentrate this nanoplankton from the water.

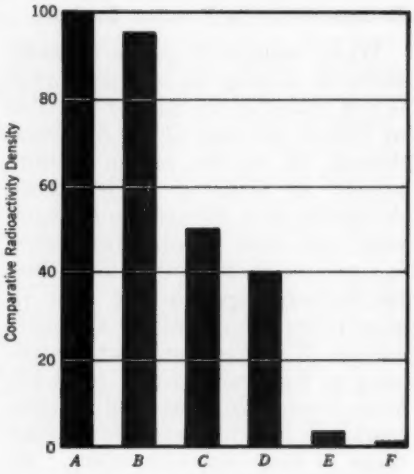

Fig. 2. Radioactivity in Different Organisms

A—*plankton*, B—*caddis fly larvae*, C—*snails*, D—*small minnows*, E—*bass*, F—*water*.

Owing to the swiftness of the water and the cobblestone-like river bed, conventional types of bottom samplers are

of little value. Near shore, rocks can be picked up by hand and the attached algae and invertebrate organisms scraped off. To obtain rocks in deep water, a drag type of dredge, triangular in cross section, is operated from the A-frame of the power boat. A clam dredge was developed recently for securing organisms living in the accumulated silt behind McNary Dam.

A large part of the radioactivity in the water and invertebrate organisms originates from isotopes with half-lives of only a few hours. Such samples must be transported to the laboratory and processed quickly, before substantial amounts of the radioactivity have faded away. Water samples more than 24 hr old are of little value, as correction factors necessary for extrapolation back to the time of sampling become excessive.

A crude indication of the radioactivity density of the samples can be obtained by placing them directly in a Geiger counter. Much of the radioactivity is of low energy, however, and is lost within the mass of the sample unless the bulk is reduced to a minimum. Water samples are evaporated to dryness, and the residue, which contains the radioisotopes as salts, is transferred in nitric acid to stainless-steel plates for counting. Biological samples, usually 1–5 g in size, are first digested in boiling nitric acid and then placed in a muffle furnace to reduce them to a white ash. The ash is then transferred to counting plates. Mica-window beta counters are used for determining the radioactivity density of the samples.

Hundreds of samples must be processed each month to follow adequately the changes that may occur in the several different types of materials tested throughout the extensive area of interest. Results are kept current, however, by recording the data on punch-cards, which are fed to electronic computers and tabulated mechanically.

Radioactivity in River Water

Like all other rivers, the Columbia contains small amounts of naturally occurring radioisotopes which contribute a background amount of radiation. Above the Hanford reactors, alpha activity density is less than 5×10^{-9} microcuries (μc) per milliliter, and beta activity density is less than 5×10^{-8} μc per milliliter. Any samples with activity densities greater than these amounts are considered to have received additions from an outside source. The detection of a short-lived beta particle emitter of 5×10^{-8} μc per milliliter is equivalent to analyzing chemically for one part in 10^{20}.

The geographic distribution of radioactivity in the river follows an expected pattern, as illustrated in Fig. 1, for the low-flow period. As the water flows downstream, its radioactivity density is increased by the effluent added from each reactor. The effluent gradually mixes with the main river flow, and not until a few miles below the reactors does maximum radioactivity appear in shore samples. Below the old townsite of Hanford, the radioactivity gradually diminishes owing to decay of the short-lived radioisotopes, dispersion throughout the width of the river, removal by sedimentation, and assimilation by living organisms. Uniform dispersal of the effluent across the river is not reached until the vicinity of North Richland, many miles below the reactors. Below Richland, the effluent is further diluted by the Yakima River, and, below Pasco, by the Snake and Walla Walla rivers. Water from the Yakima River

effectively dilutes the radioactivity concentration along the west bank, and the Snake River tends to dilute the radioactivity concentration along the east bank of the Columbia River.

The Pasco treatment plant effectively reduces the concentration of beta particle emitters from one-third to one-eighth of that in the Columbia River. A substantial portion of the radioactive materials that collect on the Pasco filters is flushed back into the Columbia River during the normal backwashing operation.

Radioactivity in Aquatic Life

Some of the radioisotopes discharged into the Columbia with the reactor effluent accumulate in aquatic organisms. Although the exposed surfaces of the organisms absorb or adsorb significant amounts of certain isotopes, by far the greatest accumulation occurs through life processes. The radioisotopes of elements essential to the growth of the organisms are concentrated from the water in substantial amounts. In some instances, where the natural supply of an essential element—notably phosphorus—is limited, the radioisotope may be several hundred thousand times more concentrated in the organism than in the surrounding water.

The radioactivity density of the different types of aquatic life varies over a broad range, as indicated in Fig. 2, for the late summer period. Such differences may be attributed to several factors:

1. Food chain relationships are of prime importance. The highest activity densities are found usually in the plankton, which, as previously mentioned, is composed almost entirely of diatoms. These minute plant cells floating in the river obtain their required nutriment directly from the elements dissolved in the water. Little time elapses in the movement of isotopes between the water and the plant cells, and relatively large amounts of the shorter-lived radioisotopes tend to accumulate. Thus, 70–90 per cent of the activity of the plankton is due to such isotopes as Na^{24}, Cu^{64}, and Mn^{56}; 10–30 per cent is from P^{32}; and 1 per cent or less is from longer-lived isotopes. Organisms that feed on the plant cells, such as the larvae of certain insects, are next in order of radioactivity. The time lag involved in converting the plant tissue into animal tissue allows some of the short-lived isotopes to decay, and in these small animal forms only 15–30 per cent of the activity is from such isotopes, while 70–80 per cent is from P^{32} and about 1 per cent or less is from longer-lived isotopes. In the fish, which feed on the smaller animal forms, only a minor part of the activity originates from Na^{24} and Cu^{64}, with P^{32} predominating. Carnivorous fish are less radioactive than species that feed on bottom organisms and plants.

2. A second factor contributing to variations in radioactivity density is the dissimilarity in chemical composition of the different forms, or more specifically, of their various tissues. The isotopes are deposited in proportion to the demand of particular tissues for the kind of element involved. As the radioactivity in fish originates almost entirely from P^{32}, phosphorus-rich structures, such as bone and scales, are most radioactive, while muscular and nervous tissue is least active.

3. Metabolic rate is a third factor influencing the level of activity density. Young, rapidly growing fish are more radioactive than old, mature

forms. Immature aquatic insects are less radioactive during resting stages than when the larvae or nymphs are feeding.

4. Body form and size, as well as the kind of skin, sheath, or shell, also are of considerable importance in relation to absorption and adsorption of radioisotopes by aquatic organisms.

Pronounced seasonal variations occur in the radioactivity densities of both the river water and aquatic organisms, as shown in Fig. 3. With uniform reactor operating levels, the radioactivity of the water is directly related to the dilution factor. During the fall and winter, when river flow is low, the radioactivity in the water is at its maximum, while during the spring freshet period, minimum activities occur. The radioactivity density of the small plant cells closely follows that of the water. In fish and other aquatic animals, however, the seasonal pattern coincides more closely with the water temperature, which is a controlling factor in metabolic rates. During the cold months the fish are

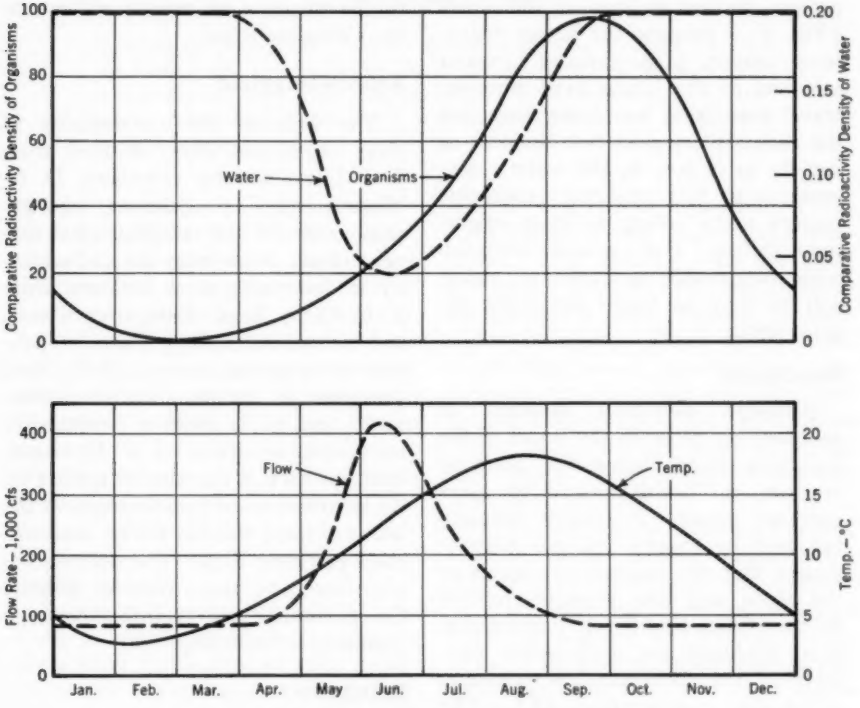

Fig. 3. Seasonal Fluctuations in Radioactivity

The radioactivity in the water is related to the dilution factor and, therefore, is at the maximum during low-flow periods; in aquatic organisms, however, the temperature is a controlling factor because of its influence on metabolic rates.

sluggish and eat only limited quantities of food organisms containing the radioactive materials; in the late summer, when temperatures are at a maximum, fish consume large quantities of the radioisotope-bearing food.

The geographic distribution of radioactivity in river organisms follows a pattern similar to that of the water (Fig. 1). Because the larger organisms contain proportionately greater amounts of the longer-lived isotopes, travel time is of less importance and the radioactivity does not diminish as rapidly as it does in the water. Exceptions to this expected geographic pattern occur owing to mass migrations of fish. For example, whitefish with measurable amounts of radioactivity may be found above the reactor areas.

Conclusion

Although detectable amounts of radioactivity occur in the water of the Columbia River below the Hanford reactors, no health hazard to users currently exists. Extensive sampling followed by careful analysis demonstrates that the radioactivity levels of the alpha and beta particle emitters in the Columbia River downstream from Richland are well below one-tenth of the recommended maximum permissible concentration (*1*). The factor of safety is further increased by filtration such as occurs at the Pasco water plant.

The amount of radioactive material deposited in the fish of the river is likewise low in comparison to accepted standards. Even if game fish were caught in the most radioactive section of the river, a person could eat the improbable amount of 20 lb daily without exceeding permissible radioactivity limits. Extensive ecological studies on the abundance of river organisms have shown no adverse effects attributable to the presence of reactor effluent in the Columbia River.

Acknowledgment

The data on the radioactivity of river organisms were obtained from J. J. Davis and his associates, D. G. Watson and C. C. Palmiter, who are responsible for the radiobiological survey. Data concerning the radioactivity of the water were obtained from Z. E. Carey, head of the control unit, and his associates, H. J. Paas (responsible for regional survey), D. L. Reid (responsible for the control laboratory), and G. E. Pilcher (responsible for control services). J. F. Honstead, who has carried out special studies on the distribution of radioisotopes in the water of the Columbia River, also supplied pertinent data. The information contributed by these General Electric Co. personnel and their assistants is gratefully acknowledged.

Reference

1. National Committee on Radiation Protection. Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water. *Natl. Bur. Standards Handbooks*, No. 52 (1953).

Progress in Radioactivity Instrumentation and Testing

Committee Report

A report of Committee E5.12—Instrumentation and Methods for Testing Radioactive Contamination in Water, presented on May 24, 1954, at the Annual Conference, Seattle, Wash., by H. H. Gerstein (Chairman), Asst. Chief Water Engr., Bureau of Water, Dept. of Water & Sewers, Chicago.

THE Committee on Instrumentation and Methods for Testing Radioactive Contamination in Water has functioned on a standby basis since it made its original report in 1952 (*1*). In the last 2 years considerable work on developing and improving methods for low-level counting of radioactive contamination in water has been carried on at the laboratories of several water departments, the US Public Health Service, and the Atomic Energy Commission. Progress has also been made in the development of more sensitive instrumentation.

During this period the AWWA, in order to keep its members informed on the subject, has published eight papers on testing for radioactivity and treatment for the removal of radioactivity from water (*1–8*). Of particular value were the papers pertaining to the statistics and limits of accuracy of low-level counting. Four articles recently published in *Nucleonics* are also of general interest in connection with low-level counting techniques for water (*9–12*). The committee has not attempted to present a complete bibliography on the subject at this time.

L. R. Setter and associates at the US Public Health Service Sanitary Engineering Center, Cincinnati, Ohio, have prepared two papers [one published (*13*)] dealing with the latest advances in low-level radioactivity measurements with internal proportional counters. These investigators report that such a procedure for low-level counting has been developed and is now undergoing slight modification before being officially adopted as the US Public Health Service standard laboratory method.

The Radiological Health Training Section of the Sanitary Engineering Center has held short courses designed to familiarize water works personnel with the existing and potential problems of radioactive contamination and decontamination of water supplies, as well as with techniques of testing for radioactive contamination.

Recommendations

It is recommended that the committee be continued on a standby basis and that it:

1. Cooperate with other interested agencies in developing a standard nomenclature for recording the amount of radioactivity in water. There is wide variation in the nomenclature used at present; counts per unit vol-

ume or unit weight, microcuries per milliliter, microcuries per liter, micromicrocuries per milliliter, and micromicrocuries per liter are all found. There is also variation in the nomenclature used for permissible emergency level standards. It is felt that there would be considerable advantage to having the same nomenclature for permissible emergency level standards as for recording results of low-level counts by the various laboratories.

2. Undertake a survey to determine the types of instrumentation used and the sensitivity of the low-level measurements being made by the various water works laboratories now conducting these tests.

References

1. Task Group Report. Instrumentation and Methods for Testing Radioactive Contamination in Water. *Jour. AWWA,* **44**:583 (Jul. 1952). Setter, L. R. Discussion. *Ibid.,* p. 592.
2. Lacy, W. J. Removal of Radioactive Material From Water by Slurrying With Powdered Metal. *Jour. AWWA,* **44**:824 (Sep. 1952).
3. Goldin, A. S.; Nader, J. S.; & Setter, L. R. The Detectability of Low-Level Radioactivity in Water. *Jour. AWWA,* **45**:73 (Jan. 1953).
4. Thomas, H. A., Jr. et al. Radioactive Fallout in Massachusetts Surface Waters. *Jour. AWWA,* **45**:562 (Jun. 1953).
5. Hursh, J. B. Radium Content of Public Water Supplies. *Jour. AWWA,* **46**:43 (Jan. 1954).
6. Lacy, W. J. & Kahn, Bernd. Survey Meters and Electroscopes for Monitoring Radioactivity in Water. *Jour. AWWA,* **46**:55 (Jan. 1954).
7. Goodgal, Sol; Gloyna, E. F.; & Carritt, D. E. Reduction of Radioactivity in Water. *Jour. AWWA,* **46**:66 (Jan. 1954).
8. Wheler, A. G., Jr.; Reynolds, S. A.; & Brooksbank, W. A., Jr. Thallium as a Reference Standard for Beta Radioactivity. *Jour. AWWA,* **46**:79 (Jan. 1954).
9. Emmons, E. H. & Lauderdale, R. A. A Method for Estimating Low Levels of Radioactive Contaminants in Water. *Nucleonics,* **10**:6:22 (Jun. 1952).
10. Freedman, A. J. & Anderson, E. C. Low-Level Counting Techniques. *Nucleonics,* **10**:8:57 (Aug. 1952).
11. Healy, J. W. Measurement of Natural Radioactivity Background. *Nucleonics,* **10**:11:14 (Oct. 1952).
12. Loosemore, L. R. Monitoring of Water for Fission Product Contamination. *Nucleonics,* **11**:11:36 (Oct. 1953).
13. Nader, J. S.; Hagee, G. R.; & Setter, L. R. Evaluating the Performance of the Internal Counter. *Nucleonics,* **12**:4:29 (Jun. 1954).

Strontium and Calcium in Municipal Water Supplies

By George V. Alexander, Ralph E. Nusbaum, and Norman S. MacDonald

A contribution to the Journal by George V. Alexander, Ralph E. Nusbaum, and Norman S. MacDonald, all of Atomic Energy Project, Univ. of California Medical School, Los Angeles. This paper is based on work performed under Contract No. At-04-1-GEN-12 between the Atomic Energy Commission and the Univ. of California at Los Angeles.

THE attention given to the radioactive isotopes of the element strontium has intensified greatly in recent years. These isotopes, Sr^{89} and Sr^{90}, are among the most potentially hazardous of the products of nuclear fission. This is true by virtue of their ease of absorption from contaminated food or water, their prolonged retention in the human skeleton, and their ability thus to impair the blood-forming functions of bone marrow and to induce bone tumors. Municipal water supplies conceivably might become contaminated with radiostrontium, as well as with other fission products, by fallout from bomb detonations, by deliberate contamination in radiological warfare, or by accidental spills and waste discharge from nuclear reactors. The expanding atomic-energy industry is producing large quantities of radioactive materials, the processing, use, storage, and disposal of which pose new problems to sanitary engineers concerned with water pollution.

The purpose of the work reported here was to determine the concentrations of natural, nonradioactive strontium in the waters provided for human consumption by cities throughout the United States. By examination of the raw and tap water of a city, the removal of natural strontium by the particular water treatment applied could be estimated. This information would aid in the evaluation of conventional water treatment practices with regard to their potential effectiveness in removing dissolved radioactive strontium.

In addition, the values for natural strontium in potable waters were needed in estimating the average daily intake of natural strontium by humans. Such data on natural strontium and calcium are of aid in attempting to predict the behavior of radioactive strontium isotopes in the human body. In an effort to extract as much information as possible from the wide distribution of samples, calcium and magnesium concentrations were also determined and some degree of correlation of observed strontium-calcium ratios with geochemical conditions was sought. An emission spectrographic procedure was developed for the determination of calcium, magnesium, and strontium.

Materials and Sample Preparation

The reagents and other materials used in this work included: [1] ethylenediaminetetraacetic acid (EDTA, prepared from the sodium salt and purified by repeated precipitation from ammoniacal solution with hydrochloric acid); [2] p-(*N*,*N*-dichlorosulfamyl)-benzoic acid ("halazone") *; [3] ammonium molybdate (analytical reagent grade) †; [4] sodium chloride ‡; [5] magnesium carbonate (reagent grade) §; [6] hydrochloric acid (reagent grade) ‖; and [7] copper electrodes (¼-in. diameter, hard, electrolytic copper rod cut into ⅛-in. lengths; one end of each rod was machined to a smooth surface; tellurium copper, which has machining properties superior to electrolytic copper, was also used in the form of rods $\frac{5}{16}$ in. in diameter). A buffer–internal standard solution was prepared by dissolving 163 mg of ammonium molybdate, 375 mg of ethylenediaminetetraacetic acid, and 3.21 g of sodium chloride in 250 ml of distilled water. In the analysis of calcium and strontium only, magnesium was added to this solution (4.38 g of magnesium carbonate and a neutral equivalent of hydrochloric acid were added per 250 ml).

Three water samples from each of 50 cities were collected in August–November 1953 and forwarded to the authors by mail in 250-ml polyethylene bottles, 5 mg of halazone being added to prevent mold growth. Using a pipet coated with a water-repellent silicone, 15 ml of each of the water samples was transferred to a plastic tube and centrifuged to remove suspended material.

To 10.0 ml of the supernatant centrifuged water was added 0.10 ml of the buffer–internal standard solution. This dilution ratio was chosen so that, in the future, very small samples of water might also be easily prepared for analysis by this method, using a clinical red blood cell dilution pipet. One drop, approximately 0.05 ml, of the prepared water sample was placed on each of two copper electrodes, which were then dried for 8 hr over phosphorus pentoxide.

Method

The spectrographic procedure used for the analysis of calcium, magnesium, and strontium in water is a modification of the "copper spark" method previously reported in the literature (*1*). This method involves the excitation of the spectra with a high-voltage spark between copper electrodes upon which a sample has been deposited. In general, the method is applied to small amounts of material—50 μg or less—in which one element predominates. To minimize the effect of the wide range of mineral content encountered in water samples, it has been necessary to incorporate a spectrographic buffer system in the analysis. For the determination of calcium, magnesium, and strontium, the buffer was 50 ppm of sodium, added as the chloride. This buffer satisfactorily eliminated interference from varying concentrations of sodium and potassium. Interference due to magnesium and, in a lesser degree, to calcium remained, however, and had to be taken into account in computing the concentrations from the observed intensity ratios. If it is necessary to analyze only for calcium and

* A product of Abbott Labs., North Chicago, Ill., was used.

† Supplied by Mallinckrodt Chem. Works, St. Louis, Mo.

‡ "Specpure," a product of Jarrell-Ash Co., Boston, Mass., was used.

§ Supplied by Merck & Co., Rahway, N.J.

‖ Supplied by Baker Chem Co., Phillipsburg, N.J.

TABLE 1

Comparison of Copper Spark, Flame Photometric, and EDTA Titration Determinations of Calcium and Magnesium

Sample No.	Copper Spark		EDTA Titration		Flame
	Ca ppm	Mg ppm	Ca ppm	Mg ppm	Ca ppm
47	13	10	13	12	15
20	20	5	15	4	16
28	40	7	43	6	34
16	42	11	36	8	38
38	42	13	36	8	38
17	44	12	37	7	37
103	58	23	81	30	62
46	62	38	72	26	77
145	64	34	84	32	62
172	70	43	72	27	78

strontium, 50 ppm of magnesium in addition to the sodium buffer has been found sufficient to eliminate "extraneous-element" effects on calcium and strontium line intensities.

The electrodes bearing the dried samples were excited with an "ARL High Precision Source" * under the following circuit conditions: primary voltage, 150 v; capacitance, 0.007 microfarad; and inductance, 410 microhenries. These values were found to give the optimum signal-to-noise ratio for the materials being analyzed. The spectrum was photographed with an ARL 2 meter grating spectrograph * (24,400 lines per inch). The region from 2,300 to 4,900 Å was recorded on Eastman SA No. 2 film.† The lines used for analysis were:

Mo	Ca	Mg	Sr
3,903.0	4,318.7	3,838.3	4,215.5
	4,302.5		4,077.7
2,816.2		2,795.5	

Neutral filters were used over several of the lines to make the analysis continuous throughout a wide range of concentration. The full sensitivity of this method was utilized only for strontium, in which instance the lower limit of sensitivity appeared to be in the vicinity of 0.001 ppm Sr. As determined from analyses of standard solutions of strontium and calcium salts, the precision of the overall analysis, expressed as the coefficient of variation, was approximately 0.10. Replicate analyses of a single prepared sample yielded a coefficient of variation of 0.02–0.04. A comparison of the values determined by the spectrographic method with those determined by direct-intensity flame photometry and by a conventional EDTA titration method (*2*) is shown in Table 1. The analytical results are presented in Table 2.

* A product of Applied Research Labs., Glendale, Calif.

† A product of Eastman Kodak Co., Rochester, N.Y.

Discussion of Results

Treatment and strontium concentration. If one considers only those tap water samples that were derived from the treatment of a single raw-water source rather than blends of uncertain makeup, it is noted that the alterations of calcium and strontium content are directly related: removal of calcium is

TABLE 2

Water Analyses

City	Sample No.	Type of Water*	Treatment†	Ca *ppm*	Mg *ppm*	Sr *ppm*	Sr per 1,000 Ca‡
Atlanta, Ga.	1	Rs		1.6	0.97	0.010	2.86
	2	T-1	*A,C,F,G,H*	13	1.9	0.031	1.09
	3	T-1	*A,C,F,G,H*	7.9	1.3	0.016	0.92
Baltimore, Md.	4	T-6	*A,C,G,J*	14	5.7	0.031	1.01
	5	T-6	*A,C,G,J*	24	5.3	0.034	0.64
	6	Rs		62	19	0.10	0.74
Birmingham, Ala.	7	Rs		48	16	0.085	0.81
	8	T	*A,C,G,K*	9.3	1.3	0.015	0.74
	9	T-7	*A,C,G*	32	9.2	0.038	0.54
Boise, Idaho	10	Tb	*G*	23	4.0	0.18	3.58
	11	Rg		17	3.3	0.12	3.22
	12	Rg		28	5.8	0.17	2.78
Boston, Mass.	13	Rs		2.7	1.0	0.022	3.72
	14	Rs		1.9	0.63	0.024	5.78
	15	Tb	*G,H*	1.9	0.71	0.027	6.50
Buffalo, N.Y.	16	Rs		42	11	0.16	1.74
	17	T-16	*A,G*	44	12	0.16	1.66
	18	T-16	*A,G*	44	13	0.18	1.87
Burlington, Vt.	19	Rs		20	6.0	0.088	2.01
	20	T-19	*A,G,J*	20	5.4	0.062	1.42
	21	T-19	*A,G,J*	19	4.9	0.068	1.63
Charleston, S.C.	22	Rs		3.6	0.37	0.0058	0.74
	23	Rs		9.2	2.4	0.025	1.24
	24	T-22	*A,G,M,N*	4.2	0.45	0.013	1.42
Charlotte, N.C.	25	Rs		2.4	0.83	0.016	3.05
	26	T-25	*A,C,F,G,H,J*	7.0	1.1	0.020	1.31
	27	T-25	*A,C,F,G,H,J*	7.2	1.0	0.017	1.08
Cheyenne, Wyo.	28	Rg	*G*	40	7.4	0.19	2.17
	29	Rg		43	7.3	0.20	2.13
	30	Tb	*A,G*	40	7.2	0.21	2.40
Chicago, Ill.	31	Rs		48	21	0.089	0.85
	32	R-31		52	26	0.12	1.05
	33	T-31	*A,B,C,F,G*	49	23	0.099	0.92

* Key: Rg, raw ground water; Rs, raw surface water; T, tap water; Tb, tap water blend; T-1, etc., tap water from same source as Sample 1, etc.

† Key: *A*, alum; *B*, ferrous sulfate; *C*, lime; *D*, phosphate; *E*, ion exchanger; *F*, activated carbon; *G*, chlorine; *H*, ammonia; *J*, fluoride; *K*, soda ash; *L*, sodium silicate; *M*, copper sulfate; *N*, caustic soda.

‡ Number of strontium atoms per 1,000 calcium atoms. This value equals 1,000 (ppm Sr/ppm Ca) (40.1/87.6).

TABLE 2—*Water Analyses (contd.)*

City	Sample No.	Type of Water*	Treatment†	Ca *ppm*	Mg *ppm*	Sr *ppm*	Sr per 1,000 Ca‡
Cincinnati, Ohio	34	Rs		43	16	0.20	2.13
	35	T-34	*B,C,F,G,H,K*	46	14	0.24	2.38
	36	T-34	*B,C,F,G,H,K*	50	15	0.25	2.29
Cleveland, Ohio	37	Rs		47	14	0.17	1.65
	38	T-37	*A,G*	42	13	0.16	1.74
Dallas, Tex.	40	Rs		41	5.2	0.22	2.45
	41	T-40	*B,C,F,G,H*	16	2.5	0.091	2.60
	42	T-40	*B,C,F,G,H*	19	2.5	0.11	2.64
Denver, Colo.	43	Rs		34	15	0.26	3.49
	44	T-43	*A,C,G,H*	32	13	0.26	3.71
	45	Rs		10	2.6	0.052	2.38
Des Moines, Iowa	46	Rs		62	38	0.18	1.33
	47	T-46	*A,C,D,G,K*	13	10	0.045	1.58
	48	T-46	*A,C,D,G,K*	13	9.0	0.039	1.37
Detroit, Mich.	49	Rs		32	12	0.10	1.43
	50	T-49	*A,F,G*	35	12	0.11	1.44
	51	T-49	*A,F,G*	32	12	0.11	1.57
Fargo, N.D.	52	Rs		38	53	0.12	1.44
	53	T-52	*A,C,G,H,J*	30	17	0.054	0.82
	54	T-52	*A,C,D,G,H,J*	21	19	0.048	1.04
Great Falls, Mont.	55	Rs		40	14	0.26	2.97
	56	T-55	*A,F,G,H*	39	13	0.23	2.69
Houston, Tex.	58	Rg		30	9.0	0.32	4.88
	59	Rg		5.8	1.8	0.12	9.46
	60	Tb	*G*	22	6.0	0.30	6.23
Indianapolis, Ind.	61	Tb	*A,G,J*	64	57	0.27	1.93
	62	Rs		74	74	0.37	2.29
	63	Rs		80	76	0.40	2.29
Kansas City, Mo.	64	Rs		70	24	0.58	3.79
	65	T-64	*A,B,C,G,H,K*	13	6.0	0.087	3.06
	66	T-64	*A,B,C,G,H,K*	17	6.8	0.082	2.20
Las Vegas, Nev.	67	Rg		45	42	0.62	6.30
	68	Rg		47	40	0.60	5.84
	69	Tb	none	40	35	0.62	7.09

* Key: **Rg**, raw ground water; Rs, raw surface water; T, tap water; Tb, tap water blend; T-1, etc., tap water from same source as Sample 1, etc.

† Key: *A*, alum; *B*, ferrous sulfate; *C*, lime; *D*, phosphate; *E*, ion exchanger; *F*, activated carbon; G, chlorine; *H*, ammonia; *J*, fluoride; *K*, soda ash; *L*, sodium silicate; *M*, copper sulfate; *N*, caustic soda.

‡ Number of strontium atoms per 1,000 calcium atoms. This value equals 1,000 (ppm Sr/ppm Ca) (40.1/87.6).

TABLE 2—*Water Analyses (contd.)*

City	Sample No.	Type of Water*	Treatment†	Ca *ppm*	Mg *ppm*	Sr *ppm*	Sr per 1,000 Ca‡
Little Rock, Ark.	70	Rs		1.8	0.84	0.011	2.79
	71	T-70	*A,C,D,G,H,J*	5.6	0.71	0.0094	0.77
	72	T-70	*A,C,D,G,H,J*	7.8	1.1	0.014	0.82
Los Angeles, Calif.:							
Metropolitan Water	172	Rs		70	43	1.0	6.53
Dist.	173	R-172		68	44	0.91	6.12
	174	T-172	*E*	34	11	0.29	3.90
Riess Well No. 2	169	Rg		72		0.42	2.64
Riess Well No. 3	170	Rg		112		0.61	2.49
Fallbrook Well	171	Rg		60		0.28	2.17
Owens Valley Aqueduct	175	T	none	22		0.14	2.95
	176	T-175	none	25		0.15	2.85
Madison, Wis.	76	T-77	*G,J*	64	120§	0.076	0.54
	77	Rg		55	73	0.054	0.45
Memphis, Tenn.	79	Rg		1.6	0.56	0.036	10.3
	80	Rg		7.6	5.5	0.016	0.96
	81	Tb	*F*	2.5	3.3	0.021	3.84
Miami, Fla.	82	Rg		101	11	1.3	5.89
	83	Rg		44	3.4	0.59	6.13
	84	Tb	*C,G,J*	30	4.4	0.47	7.16
Milwaukee, Wis.	85	Rs		47	18	0.11	1.07
	86	T-85	*A,G,H,J*	39	16	0.090	1.05
	87	T-85	*A,G,H,J*	42	17	0.097	1.05
Minneapolis, Minn.	88	Rs		44	25	0.061	0.64
	89	T-88	*A,C,G,H*	22	5.2	0.037	0.75
	90	T-88	*A,C,G,H*	19	4.2	0.029	0.70
New Orleans, La.	145	Rs		64	34	0.46	3.28
	146	T-145	*B,C,D,F,G,H*	21	22	0.14	3.05
	147	T-145	*B,C,D,F,G,H*	21	22	0.14	3.05
New York, N.Y.	94	Rs		6.8	2.0	0.016	1.08
	95	Rs		19	7.8	0.024	0.58
	96	Tb	*G*	15	4.6	0.018	0.55
Norfolk, Va.	97	Rs		4.9	2.2	0.027	2.52
	98	Rs	*M*	14	6.5	0.062	2.02
	99	Tb	*A,C,F,G,J*	28	3.7	0.060	0.98

* Key: Rg, raw ground water; Rs, raw surface water; T, tap water; Tb, tap water blend; T-1, etc., tap water from same source as Sample 1, etc.

† Key: *A*, alum; *B*, ferrous sulfate; *C*, lime; *D*, phosphate; *E*, ion exchanger; *F*, activated carbon; *G*, chlorine; *H*, ammonia; *J*, fluoride; *K*, soda ash; *L*, sodium silicate; *M*, copper sulfate; *N*, caustic soda.

‡ Number of strontium atoms per 1,000 calcium atoms. This value equals 1,000 (ppm Sr/ppm Ca) (40.1/87.6).

§ Accuracy uncertain.

TABLE 2—*Water Analyses (contd.)*

City	Sample No.	Type of Water*	Treatment†	Ca *ppm*	Mg *ppm*	Sr *ppm*	Sr per 1,000 Ca‡
Oklahoma City, Okla.	100	T-101	*A,C,D(?),F,G*	26	12	0.41	7.21
	101	Rs		48	28	1.4	13.3
	102	R-101		52	28	1.7	15.0
Omaha, Neb.	103	Rs		58	23	0.50	3.94
	104	T-103	*A,C,G,J*	70	24	0.60	3.92
	105	T-103	*A,C,G,J*	68	24	0.57	3.83
Philadelphia, Pa.	106	Rs		23	9	0.031	0.61
	107	Rs		45	28	0.18	1.83
	108	Tb	*A,C,G*	34	15	0.10	1.34
Phoenix, Ariz.	109	Rs		40	44	0.72	8.23
	110	Rg	*G*	56	58	0.78	6.37
	111	Tb	*A,G*	38	43	0.52	6.26
Pittsburgh, Pa.	112	Rs		17	7.0	0.054	1.45
	113	T-112	*G,J,K*	17	7.9	0.054	1.45
	114	T-112	*G,J,K*	15	8.0		
Portland, Me.	115	Rs		2.3	0.51	0.012	2.39
	116	R-115		2.2	0.57	0.013	2.70
	117	T-115	*G,H*	2.8	0.49	0.014	2.29
Portland, Ore.	118	Rs		1.4	0.61	0.011	3.60
	119	R-118		2.1	0.72	0.013	2.83
	120	T-118	*G,H*	2.0	0.67	0.013	2.97
Providence, R.I.	121	Rs		1.8	0.51	0.012	3.05
	123	T-121	*B,C,G,J*	7.2	0.44	0.014	0.88
Rapid City, S.D.	124	Rg		37	27	0.086	1.06
	125	Rg		48	36	0.56	5.33
	126	Tb	*G*	40	34	0.19	2.17
St. Louis, Mo.	130	Rs		68	22	0.53	3.56
	132	T-130	*A,B,C,G,H*	18	14	0.13	3.30
	133	Rs	*G,H*	42	19	0.27	2.94
Salt Lake City, Utah	134	Rs	*G,H*	47	17	0.30	2.92
	135	Tb	*G,H*	50	18	0.38	3.48
San Diego, Calif.	136	T-137	*C,B,G,J,L*	50	27	0.68	6.22
	137	Rs		60	28	0.76	5.79
	138	Rs		42	23	0.20	2.18

* Key: Rg, raw ground water; Rs, raw surface water; T, tap water; Tb, tap water blend; T-1, etc., tap water from same source as Sample 1, etc.

† Key: *A*, alum; *B*, ferrous sulfate; *C*, lime; *D*, phosphate; *E*, ion exchanger; *F*, activated carbon; *G*, chlorine; *H*, ammonia; *J*, fluoride; *K*, soda ash; *L*, sodium silicate; *M*, copper sulfate; *N*, caustic soda.

‡ Number of strontium atoms per 1,000 calcium atoms. This value equals 1,000 (ppm Sr/ppm Ca) (40.1/87.6).

TABLE 2—*Water Analyses (contd.)*

City	Sample No.	Type of Water*	Treatment†	Ca ppm	Mg ppm	Sr ppm	Sr per 1,000 Ca‡
San Francisco, Calif.	139	Rs		19	8.4	0.13	3.13
	140	Rs		14	4.9	0.10	3.27
	141	T-139	*G,J*	18	8.0	0.12	3.05
Santa Fe, N.M.	142	Rg		61	8.2	0.14	1.05
	143	Rs		63	7.6	0.13	0.94
	144	T-142	*D,G*	10	3.9	0.033	1.51
Seattle, Wash.	91	Rs		7.6	2.0	0.020	1.20
	92	R-91		8.0	1.9	0.022	1.26
	93	T-91	*G,H*	6.8	1.7	0.019	1.28
Washington, D.C.	127	Rs		37	17	0.23	2.84
	129	T-127	*A,C,G,J*	38	21	0.20	2.41
Wichita, Kan.	73	Rg		39	9.4	0.28	3.28
	74	Rg		160§	0.41	1.9	5.4
	75	T-73	*B,C,D,G,H*	22	9.4	0.17	3.53

* Key: Rg, raw ground water; Rs, raw surface water; T, tap water; Tb, tap water blend; T-1, etc., tap water from same source as Sample 1, etc.

† Key: *A*, alum; *B*, ferrous sulfate; *C*, lime; *D*, phosphate; *E*, ion exchanger; *F*, activated carbon; *G*, chlorine; *H*, ammonia; *J*, fluoride; *K*, soda ash; *L*, sodium silicate; *M*, copper sulfate; *N*, caustic soda.

‡ Number of strontium atoms per 1,000 calcium atoms. This value equals 1,000 (ppm Sr/ppm Ca) (40.1/87.6).

§ Accuracy uncertain.

accompanied by removal of strontium —a not unexpected finding. In raw samples with low calcium concentrations, however, chemical treatment often increases the calcium without adding detectable amounts of strontrium. Figure 1 shows the relationship between the percentage changes in calcium and strontium levels resulting from chemical treatment of raw-water samples.

The effectiveness of various types of chemical treatment in removing strontium is compared in Table 3. Samples that were blends of several raw waters were not included in this table, nor were raw samples of such low initial calcium content that the chemical treatment increased the calcium burden. Where the change in strontium burden was 10 per cent or less, it was considered insignificant and was counted as a zero value in computing the average. The sample was nevertheless included in the total number for its group. Most of the samples of tap water had also received one or more of the following treatments: chlorine, fluoride, activated carbon, and ammonia. Further classification of the samples into additional categories, based upon whether or not any of the latter treatments had been used, did not, however, seem profitable.

It is apparent that water treatment involving coagulation and filtration, with or without softening, reduces the burden of dissolved strontium by considerable amounts. Direct comparison of the relative efficiencies of the various treatments on the basis of the average values given in Table 3 is not warranted, as pertinent factors such as pH, chemical composition of the raw water, and concentrations of reagents added are unknown.

TABLE 3

Strontium Removal by Chemical Treatment

Type of Treatment	Sr Removal—*per cent*		No. of Cities
	Avg	Range	
Alum or ferrous sulfate	12	10–31	7
Alum or ferrous sulfate, plus lime	37	10–75	11
Alum or ferrous sulfate, plus lime and soda ash	54	10–85	3
Alum or ferrous sulfate, plus lime and phosphate	42	10–70	5
Softening only (phosphate, ion exchanger)	73	69–76	2
None (except chlorine, fluoride, carbon, or ammonia)	10		8

Where softening agents were applied, the amounts used were calculated to reduce calcium and magnesium hardness to a desired level, so that optimum conditions for removal of strontium may or may not have existed. Nevertheless, the *maximum* removals of dissolved strontium resulting from each type of treatment indicate that alum is much less effective than when used in combination with softening agents like lime–soda ash, phosphates, or ion exchangers (compare Samples 7–9). These conclusions, based on the effects of operations routinely performed in actual water treatment plants, are in general agreement with the results of published laboratory and pilot plant studies designed to assay the value of such treatments in decontamination of waters (*3–12*). The authors' observations of as high as 85 per cent dissolved-strontium removal with conventional water softening procedures, when taken together with the published pilot plant studies, indicate that it would be possible to remove more than 90 per cent in the event of serious contamination of large volumes of water. It should be emphasized, however, that, if the level of activity of Sr^{90} is more than 20×10^{-6} microcuries per milliliter, even a 90 per cent removal of dissolved strontium (natural plus Sr^{90}) will fail to reduce the contamination below the maximum permissible for drinking water. In such a situation, single-stage precipitation is inadequate, as pointed out by Goodgal and colleagues (*12*).

Strontium-calcium ratios. The computed values (Table 2) for the number of strontium atoms accompanying every 1,000 calcium atoms in the samples, before and after treatment, fail to demonstrate that any of the chemical treatments are more effective in removing one or the other of these elements. If such selectivity exists, as it well may, these data are insufficient to prove it. The same may be said for the calcium-magnesium ratios which were computed but are not presented here.

Strontium concentration in surface waters. An attempt to correlate the strontium concentration in surface water with the soil characteristics of the drainage basin from which the water was obtained appeared to meet with reasonable success. As noted in Table 2, the range of strontium concentration for raw surface waters was 0.006–1.5 ppm. According to references (*13–15*) consulted by the authors, the drainage basin soils may be divided into three categories: [1] noncalcareous, [2] noncalcareous plus cal-

careous, and [3] calcareous. The strontium concentration ranges of the waters from these three groups of soils are 0.006–0.20, 0.10–0.26, and 0.27–1.5 ppm, respectively. The mean concentrations are, respectively, 0.05, 0.20, and 0.6 ppm. Some overlapping in the classification is to be expected, owing to the lack of detailed soil maps for each drainage area being considered. The lowest values for the samples reported in Table 2 appear to be associated with the red and yellow podsolic, alpine meadow, bog, and ground

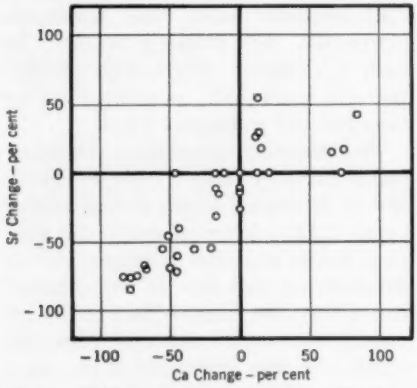

Fig. 1. Relation of Strontium and Calcium Concentration Changes

In general, there appears to be a direct relationship.

water podsol soils. The highest value (Samples 101 and 102) is apparently associated with soils containing large amounts of easily leached, soft lime carbonate, such as the reddish chestnut soil of the Oklahoma Panhandle.

Strontium-calcium ratios of surface and ground waters. In Fig. 2, the relationship between the strontium-calcium ratio and the strontium concentration is presented for both surface and ground raw waters. The high strontium concentration region of this curve is poorly defined, because of the limited number of samples considered. The surface water samples from Oklahoma City (No. 101 and 102) fall on the line representing a steady increase in Sr:Ca ratio with increasing strontium concentration, whereas the two ground water samples with high strontium concentration (No. 82 and 74) indicate a plateau beyond a strontium concentration of 0.8 ppm. The remainder of the plot shows that there is little, if any, difference between the surface and ground waters studied in this survey. One possible exception is the 2,580-ft well water sample from Houston, Tex. (No. 59). It is seen that no single, simple relation encompasses all the values. Two possible trends are shown by the solid and the dotted lines.

In general, it appears that the authors' results do not support Odum's view (*16*) that the Sr:Ca ratios of ground waters should be higher than those of surface waters. It does not seem advisable, however, to draw any definite conclusions on this point until a more detailed survey has been made.

When the data of Table 2 are plotted as Sr:Ca ratio versus calcium concentration, the curve approximates a straight line parallel to the concentration axis. No evidence for the hyperbolic form of this curve, as presented by Odum, was observed.

A comparison of the Sr:Ca ratios for a number of cities in the Mississippi drainage basin indicates that the primary contributions to the high Sr:Ca ratio observed below St. Louis, Mo., are due to the Missouri and Arkansas systems. A comparison of the drainage data available for the Mississippi system (*17*) with the observed Sr:Ca ratios supports the conclusion that the Platte, Canadian, Arkansas, Missouri, and other rivers draining the region west of the Mississippi con-

trlbute waters with Sr:Ca ratios of 4–10:1,000, whereas the Upper Mississippi, Illinois, Ohio, and other rivers draining from the north and east contribute waters with Sr:Ca ratios of 1–3:1,000.

A comparison of the Sr:Ca ratios at various points in the Great Lakes system apparently supports the conclusion reached by Odum that, in a closed lake or lake system, calcium will precipitate more easily than strontium and, therefore, the Sr:Ca ratio will increase in the lake water (compare Samples 16, 31, 37, 49, and 85).

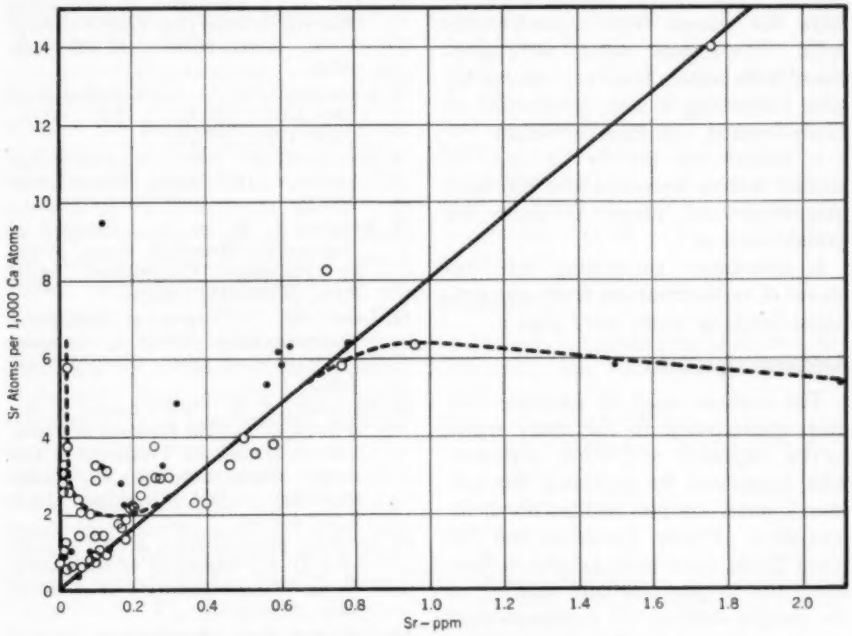

Fig. 2. Strontium-Calcium Ratio Versus Strontium Concentration

○ *Raw surface waters;* ● *raw ground waters.*

Summary

1. Samples of raw and tap water were obtained from 50 cities located throughout the United States. Analyses for strontium, calcium, and magnesium were made by an emission spectrographic technique that required no preliminary concentration of the water samples.

2. The range of dissolved-strontium concentrations in raw waters was 1.9–0.0058 ppm, with a mean of 0.29 ppm. Tap water concentrations ranged from 0.68 to 0.0094 ppm, with a mean of 0.16 ppm.

3. Comparisons made before and after chemical treatment indicated that a reduction of strontium concentration accompanies the removal of calcium. Coagulation and filtration, with or without softening, reduce the burden of dissolved strontium. Alum, however, is apparently much less effective alone than in combination with soften-

ing agents such as lime–soda ash, phosphates, or ion exchangers. In several cities, as much as 75 per cent of the strontium in the raw water is removed during routine water softening procedures.

4. The strontium concentrations of raw surface waters were related to the predominant soil type in their drainage basins. The lowest values observed were for waters from noncalcareous soils. The highest values were associated with waters from regions having soils containing a large proportion of easily leached, soft lime carbonate.

5. Values for the Sr:Ca ratio of surface waters were of about the same magnitude and range as those for ground waters.

6. Inferences concerning the removal of radiostrontium from contaminated drinking water were drawn.

Acknowledgment

The authors wish to express their deep appreciation to the many water works engineers and other personnel who cooperated by providing the necessary water samples and pertinent information. Florita Ezmirlian and Patricia Spain were most helpful in handling the preparation and mailing of the sample bottles. It is also desired to acknowledge the helpful consultations with M. R. Huberty, Dept. of Irrigation and Soils, University of California at Los Angeles.

References

1. Fred, M.; Nachtrieb, N. H.; & Tomkins, F. S. Spectrochemical Analysis by the Copper Spark Method. *J. Am. Optical Soc.*, **37**:279 (1947).
2. Betz, J. D. & Noll, C. A. Total Hardness Determination by Direct Colorimetric Titration. *Jour. AWWA*, **42**: 49 (Jan. 1950).
3. Lauderdale, R. A. & Emmons, A. H. A Method for Decontaminating Small Volumes of Radioactive Water. *Jour. AWWA*, **43**:327 (May 1951).
4. Eliassen, Rolf, et al. Studies on Radioisotope Removal by Water Treatment Processes. *Jour. AWWA*, **43**:615 (Aug. 1951).
5. Straub, C. P.; Morton, R. J.; & Placak, O. R. Studies on the Removal of Radioactive Contaminants From Water. *Jour. AWWA*, **43**:773 (Oct. 1951).
6. Lacy, W. J. Removal of Radioactive Material by Slurrying With Powdered Metal. *Jour. AWWA*, **44**:824 (Sep. 1952).
7. Lauderdale, R. A. Decontamination of Radioactive Water. *AEC Rpts.*, Wash–**129**:1 (1952).
8. Straub, C. P. Water Decontamination Studies. *AEC Rpts.*, Wash–**129**:84 (1952).
9. Nesbitt, J. B., et al. Removal of Radioactive Strontium From Water by Phosphate Coagulation. *AEC Rpts.*, NYO–4435 (1952).
10. Lacy, W. J. Removing Radioactive Materials From Water by Coagulation. *Wtr. & Sew. Wks.*, **100**:410 (1953).
11. Downing, A. L.; Wheatland, A. B.; & Eden, G. E. The Removal of Radioisotopes During the Treatment of Domestic Water Supplies. II. Radiostrontium. *J. Inst. Wtr. Engrs.* (Br.), **7**:555 (1953).
12. Goodgal, Sol; Gloyna, E. F.; & Carritt, D. E. Reduction of Radioactivity in Water. *Jour. AWWA*, **46**:66 (Jan. 1954).
13. *Soils and Men. Yearbook of Agriculture.* US Dept. of Agriculture, Washington, D.C. (1938).
14. River Basin Maps Showing Hydrologic Stations. US Weather Bureau, Washington (1949).
15. Lohr, E. W., et al. The Industrial Utility of Public Water Supplies in the United States, 1952. *USGS Circ.*, No. 197, 203, 206, 221, 232, 253, 269, 283, 288 (1952–53).
16. Odum, H. T. The Biogeochemistry of Strontium. Doctoral dissertation, Yale Univ., New Haven, Conn. (1950).
17. Stages and Discharges, Mississippi River. Mississippi River Com., Vicksburg, Miss. (1952).

Studies of Monobed Deionization

By N. Krishnaswamy

A contribution to the Journal by N. Krishnaswamy, National Chemical Laboratory of India, Poona, India.

THE recently developed technique of monobed deionization, in which cation- and anion-exchange resins are intimately mixed in equivalent proportions in the same column, has several advantages over the conventional two-column deionization system. The availability in bead form of some of the resins with strongly acidic or basic and weakly acidic or basic properties allows different combinations to be employed for suitable deionization purposes. In this investigation, only combinations of weakly acidic cation exchangers with weakly basic anion exchangers have been studied, because such combinations are said to offer the highest regeneration efficiency (*1*). Using sodium chloride solutions of different concentrations, Kunin and McGarvey (*2*) observed that, with a combination of Amberlite IRC-50 * and Amberlite IR-4B, "because of the poor rate of reaction and poor equilibrium conditions, it becomes necessary to limit the operation of the system to low flow rates, small particle sizes and high influent concentrations."

To examine the nature of the ion removal obtained and the regeneration efficiency, the following two systems were studied, employing low rates of flow and a synthetic brackish water: System *A*—Amberlite IRC-50 and Amberlite IR-4B; and System *B*—Amberlite IRC-50 and Amberlite IR-45. Under the experimental conditions described in this investigation, both systems have shown good reduction in the total ionic concentration from a brackish water, and the regeneration efficiency has been found to be high.

* All resins specifically referred to in this paper are products of Rohm & Haas Co., Philadelphia.

Procedure

System A. Amberlite IRC-50 (30–40 mesh) and Amberlite IR-4B (20–30 mesh), with a total available exchange capacity of 345 milliequivalents, were regenerated and packed, with intimate mixing, in a column 0.55 in. in diameter, having a coarse, sintered-glass disk support fused at the bottom. Synthetic brackish water (average composition given in Table 1) was percolated at a slow rate until a total volume of 4,000 ml had passed through, the effluent being collected in 1,000-ml lots for analysis. After two experimental

TABLE 1

Average Composition of Brackish Water

Item	Quantity ppm
Ca (as $CaCO_3$)	1,015
Na	392
Cl	680
SO_4 (as Na_2SO_4)	1,112
Total alkalinity (as $CaCO_3$)	155
Total solids	2,671

TABLE 2

Ion Removal, System A

Expt. No.	Item	Vol. of Effluent Collected—*ml*						
		500	1,000	1,500	2,000	2,500	3,000	4,000
		Removal—*per cent*						
	0.55-in. Column, 1,000-ml Lots							
1	Ca*		80.8		60.3		66.7	46.7
2			88.0		70.0		63.4	55.0
1	Total alkalinity*		79.8		62.9		65.7	57.2
2			70.3		62.8		50.5	48.6
1	Total solids		54.7		36.6		38.2	59.7
2			40.5		28.2		29.1	29.9
1	SO_4†		66.7		59.3		61.2	46.3
2			70.0		50.9		42.0	35.0
1	Cl		38.9		11.1		11.1	5.6
2			43.5		18.4		12.4	9.8
	0.37-in. Column, 500-ml Lots							
A1	Ca*	100.0	97.0	89.8	89.2	89.2*	87.4	
A2		92.2	88.2	87.3	87.3	91.2‡	87.3	
A3		96.9	95.1	93.1‡	92.2	92.2	92.2	
A4		96.0	94.1	91.2	91.2‡	91.2	91.2	
A1	Total alkalinity*	37.2	22.9	22.9	20.0	48.6‡	22.9	
A2		32.0	32.0	32.0	24.0	30.0‡	16.0	
A3		53.6	26.8	44.7‡	26.8	14.3	5.4	
A4		56.2	35.9	34.4	46.9‡	28.1	18.8	
A1	Total solids	98.2	91.1	66.0	58.7	63.9‡	52.7	
A2		83.8	65.3	59.2	53.8	68.1‡	53.4	
A3		71.2	59.6	65.6‡	54.3	51.7	52.7	
A4		76.0	65.4	60.7	64.1‡	54.3	52.3	
A1	SO_4†	100.0	96.3	88.8	90.6	94.3‡	92.5	
A2		81.2	84.9	86.8	86.8	94.3‡	89.6	
A3		55.7	71.7	86.8‡	83.0	82.0	81.1	
A4		66.0	83.0	88.7	94.3‡	92.4	92.4	
A1	Cl	100.0	100.0	63.5	38.5	40.4‡	19.2	
A2		92.3	51.9	30.8	19.2	36.5‡	13.5	
A3		79.6	39.3	39.3‡	13.0	11.1	13.0	
A4		86.1	49.2	32.4	36.9‡	10.5	0	
A1–A4	Na	negligible						

* As $CaCO_3$. † As Na_2SO_4. ‡ Percolation intermittently discontinued.

runs, the resins were transferred to a narrower column (diameter 0.37 in.), thus increasing the depth of the bed. Using low flow rates, the percolation was continued until 3,000 ml of the brackish water had passed through the bed. The effluent was collected in 500-ml lots. Four cycles were studied with regeneration after percolation of 3,000 ml of brackish water.

In the efficient separation of the two components in a monobed combination for regeneration purposes, the density of the resins and their shape play an important part. If the resins are in bead form and have different densities, they can be stratified into two zones by backwashing with a suitable liquid, and regeneration can then be effected. In this system, however, the fact that Amberlite IRC-50 is in bead form while Amberlite IR-4B is in granular form offers difficulty in separation. Although, in commercial practice, the two zones are regenerated through different inlets in specially designed apparatus, in this investigation the bed was backwashed slowly until the two zones were stratified and the lighter top layer was then drawn out of the tube by increasing the backwash rate. The resin thus forced out was collected in another tube and regenerated.

Because complete separation of the two resins was not possible with water and alcohol as the backwash liquids, another procedure was subsequently adopted. A small amount of alcohol was drained through the exhausted resin bed, and air was drawn through the column until the resins were dry. The mixture was then transferred in small lots to a 30-mesh sieve. On sieving, it was found that most of the Amberlite IRC-50 passed through with a very small amount of Amberlite IR-4B. It was observed that some of the cation exchanger beads had become swollen, as was to be expected, owing to the alcohol treatment and to conversion from the hydrogen to the calcium form. These beads remained on the sieve with the major portion of the anion exchanger. The two fractions were packed separately in two columns and regenerated, using 1.0 per cent sulfuric acid (1,680 ml) and 5.0 per cent sodium carbonate solution (367 ml) for the cation and anion exchangers, respectively. The spent regenerant and the washings were analyzed to calculate the exact amount of regenerant used up, and these results were compared with the amount of cations and anions removed during the experimental run.

After regeneration and washing, the resins were remixed intimately and another cycle was studied. In this manner, two runs were carried out with a low bed depth and four with a high bed depth. The results are presented in Table 2. At different periods during the runs, the percolation was discontinued for a short time. The effect of such breaks on ion removal is denoted by "‡" in Table 2.

System B. Amberlite IRC-50 (20–30 mesh) and Amberlite IR-45 (passing 30 mesh), with a total available exchange capacity of 262.8 milliequivalents, were regenerated and packed, with intimate mixing, in a column 0.55 in. in diameter, having a coarse, sintered-glass disk support at the bottom. As Amberlite IR-45 is very light, the relatively large volume of resin made it impossible to employ the 0.37-in. column used for System *A*.

The percolation of the brackish water was continued at low flow rates until 3,000 ml had passed through, the effluent being collected in 500-ml lots for analysis. The exhausted bed was

backwashed with tap water at controlled rates, and, on stratification, the top layer of Amberlite IR-45 was easily forced out of the tube. Complete separation of the two resins was obtained in this system. The two resins were cation and anion exchangers, respectively.

Four runs were conducted with regeneration after 3,000 ml of the brackish water had been percolated. The ion reductions obtained are shown in Table 3. The four runs were carried out without any break in percolation.

TABLE 3

Ion Removal, System B

Expt. No.	Item	Vol. of Effluent Collected—*ml*					
		500	1,000	1,500	2,000	2,500	3,000
		Removal—*per cent*					
B1	Ca*	82.8	58.1	50.4	45.7	41.6	37.7
B2		88.4	79.4	67.8	58.6	53.3	47.8
B3		96.7	90.6	84.9	64.9	57.3	49.7
B4		88.8	73.4	63.1	55.8	49.6	43.4
B1	Total alkalinity*	60.0	60.0	57.5	55.0	52.5	50.0
B2		85.7	77.9	68.8	68.8	67.5	65.0
B3		71.5	60.0	62.9	65.7	61.6	64.7
B4		80.0	71.3	61.5	60.0	57.2	55.8
B1	Total solids	62.2	34.0	29.3	24.6	26.2	23.2
B2		60.3	42.9	39.7	33.2	30.2	24.7
B3		60.5	47.9	43.9	34.0	28.8	25.3
B4		60.9	40.7	38.2	32.2	30.3	24.6
B1	SO_4†	81.6	70.0	64.2	45.8	37.4	34.6
B2		46.6	58.4	49.5	43.7	43.7	38.9
B3		63.8	69.5	60.0	52.4	44.8	41.0
B4		40.0	45.0	46.0	41.0	39.0	37.0
B1	Cl	31.6	1.8	1.8	5.3	5.3	1.8
B2		60.7	30.3	16.1	14.3	11.6	8.9
B3		52.6	28.1	17.6	19.1	11.4	10.5
B4		76.1	35.8	22.4	17.9	13.4	11.9
B1–B4	Na	negligible					

* As $CaCO_3$.
† As Na_2SO_4.

regenerated separately, and the spent regenerants and washings were analyzed as previously. Solutions of 1.0 per cent sulfuric acid (1,500 ml) and 4.0 per cent sodium hydroxide (300 ml) were used for regenerating the

Regeneration Efficiencies

Table 4 gives the bed depths, flow rates, amount of regenerant consumed,

and amount of cations and anions removed in both systems. The percentage regeneration efficiency was calculated by dividing the milliequivalents of cations (or anions) removed by the milliequivalents of acid (or base) used up and then multiplying by 100.

Chemical Determinations

The effluents collected in the experiments were individually analyzed. The total alkalinity was determined by titrating an aliquot with standard sulfuric acid, using methyl orange as the indicator. The total-solids content was determined by evaporating 100 ml of the sample in weighed silica dishes, drying at 100°–110°C for 1 hr, cooling, and weighing. The sulfate content was determined by the addition of benzidine chloride and titration with standard sodium hydroxide solution (3). The chloride content was determined by titration with standard silver nitrate solution, using potassium chromate as the indicator. Calcium and sodium concentrations were determined within 5 per cent by the aid of a flame photometer.

Discussion of Results

System A. It can be seen from Tables 2 and 4 that, for a bed depth of 16.93 in., when 3,000 ml of brackish water had been percolated, the percentage removals of calcium, sulfate, and total solids averaged 66.4, 53.9, and 39.6, respectively. On increasing the bed depth to 38.0 in., using the same quantity of resins in a narrower column, these figures became 91.8, 85.9, and 64.3, respectively. Thus, an increase in bed depth favors an increase in the percentage reduction of calcium, sulfate, and total solids.

Longer contact due to breaks in percolation appears to improve the removal of total alkalinity, total solids, sulfate, and chloride, but the removal of calcium is not affected. Kunin and McGarvey (*2*), using electrical-resistance determinations, compared the quality of effluents obtained from monobed and conventional deionization systems after intermittent operations. They state that the monobed deionization system is capable of readsorbing all traces of electrolytes that may accumulate in the surrounding solution from the resin during breaks in percolation. In this system, longer contact time has enabled a greater reduction of the constituents, as is to be expected from the prevailing slow rates of reaction.

The fact that there is no reduction in sodium content is in agreement with the observations of Kunin and Barry (*4*), who studied the equilibrium and column behavior of Amberlite IRC-50, a carboxylic, weakly acid cation exchanger, and showed that the carboxyl group has an increased affinity for calcium ions over sodium ions and that salts like sodium chloride were ineffective with this type of exchanger.

Owing to difficulty in achieving complete separation of the two resin components, the amounts of regenerants consumed tend to appear higher than the amounts of cations and anions removed (Table 4).

System B. The bed depth in the experiments with System *B* was approximately 21 in. Even at this relatively shallow depth, the ion removal percentages are quite good and the total alkalinity reduction is very efficient. In this system, also, the reduction in sodium content is negligible, for the same reason as in System *A*.

Ease of complete separation of the two components enables good regeneration efficiency to be obtained, as indicated by the results in Table 4. The findings substantiate the statement by Kunin and Barry (*4*) that, even with an acid concentration as low as 1.0 per cent, Amberlite IRC-50 can be efficiently regenerated. System *B* (which constitutes Amberlite MB-6) has been "particularly recommended for very large installations in which deep beds of resin are possible and in which efficiency of regeneration is a more important consideration than the quality of treated effluent" (*5*). That this system is useful only for the reduction of the ionic solids content of process liquids (*5*) has been shown by the results obtained in this investigation with a synthetic brackish water.

TABLE 4

Regeneration Efficiency

1	2	3	4	5	6	7	8	9	10	11
Expt. No.	Bed Depth *in.*	Flow Rate *gpm/sq ft*	Ions in Total Vol. Percolated		Ions Removed		Consumed in Regeneration		Exchanger Regeneration Efficiency	
			Cations *meq**	Anions *meq**	Cations *meq**	Anions *meq**	Acid *meq**	Alkali *meq**	Cation† *per cent*	Anion‡ *per cent*
System *A*										
1	16.93	1.14	141.0	138.4	47.6	49.4	52.9	59.1	88.9	83.6
2	16.93	1.00	147.6	134.6	56.4	47.0	60.7	53.7	92.2	87.5
A1	37.50	0.94	110.9	102.7	73.0	77.4	81.8	86.0	89.2	90.0
A2	38.00	0.94	113.9	102.0	57.7	63.1	62.1	65.6	92.9	96.1
A3	38.00	1.00	114.6	112.4	58.5	53.0	61.3	59.6	82.1	88.9
A4	38.00	0.89	114.6	113.7	59.6	61.1	67.1	65.9	88.8	92.7
System *B*										
B1	20.8	1.14	108.9	103.5	39.1	31.0	40.0	32.0	97.7	96.9
B2	20.8	1.07	112.4	110.8	41.8	33.9	42.8	35.0	97.7	96.8
B3	20.9	1.04	105.0	102.7	45.0	38.1	45.5	38.8	99.8	98.2
B4	21.4	1.13	101.4	99.4	41.6	29.8	42.1	30.5	98.8	97.7

* Milliequivalents.
† Obtained by dividing Col. 6 by Col. 8 and multiplying by 100.
‡ Obtained by dividing Col. 7 by Col. 9 and multiplying by 100.

Summary and Conclusions

1. Two combinations of weakly acidic and weakly basic ion-exchange resins have been studied for monobed deionization.

2. System *A*, made up of Amberlite IRC-50 and IR-4B, and System *B*, made up of Amberlite IRC-50 and IR-45, exhibit a good reduction of calcium content in the presence of sodium and a good reduction of sulfate content in the presence of chloride.

3. The influence of bed depth on the removals has been studied for System

A, and the removals are found to increase with bed depth. Also, the low rate of reaction attributed to this system has been confirmed.

4. The regeneration efficiency of the two systems is high. System *B* is to be preferred in application, owing to the ease of separation of the resins for regeneration.

5. Employing deep beds and low flow rates, these systems produce a reduction in the total ionic concentration. This may find application in the treatment of brackish waters for agricultural purposes.

Acknowledgment

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References

1. KUNIN, R. & MYERS, R. J. *Ion-Exchange Resins.* John Wiley & Sons, New York (1950). p. 114.
2. KUNIN, R. & MCGARVEY, F. X. Monobed Deionization With Ion-Exchange Resins. *Ind. Eng. Chem.*, **43**:734 (1951).
3. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Wtr. Wks. Assn., New York (9th ed., 1946). p. 84.
4. KUNIN, R. & BARRY, R. E. Equilibrium and Column Behavior of Exchange Resins—Carboxylic, Weak-Acid Type, Cation-Exchange Resins. *Ind. Eng. Chem.*, **41**:1269 (1949).
5. Amberlite MB-6 (Preliminary Notes). Rohm & Haas Co., Philadelphia (May 1950).

Meeting Air-conditioning Growth

By C. K. Mathews

A paper presented on Apr. 8, 1954, at the Kansas Section Meeting, Emporia, Kan., by C. K. Mathews, Partner, Burns & McDonnell Eng. Co., Kansas City, Mo.

THE necessity or desirability of conserving water used in air conditioning is considered differently by the water consumer, the utility, and the city. The consumer is concerned directly only if his individual costs are affected. For instance, if the cost of water is low, the consumer will not be directly interested in conserving water. The water utility is concerned when the capacity of its facilities or source of supply may be exceeded. The city, apart from being the owner of the water utility, is concerned, as a proprietor, with the effect on storm and sanitary sewers and on sewage treatment plants. Of course, the city, in its governmental aspect, is very much concerned if the health or economic welfare of the community may be affected by a shortage of water.

TABLE 1

*Factory Shipments of Room Air Conditioners**

Year	No. of Units	Retail Value *$1,000,000*
1947	42,900	20
1948	76,500	33
1949	95,500	39
1950	195,000	72
1951	237,500	87
1952	341,000	123

* Data quoted in Reference 1.

It may be asked why air conditioning should be considered specially, instead of merely as another possible use for water. The answer is twofold: first, there has been a tremendous increase in consumer demand for air conditioning since World War II; and, second, water use in nonconserved air conditioning has an abnormally poor annual load factor. An air-conditioning installation provided with conservation equipment requires a relatively small quantity of water per day (about 5 per cent of that required for a nonconserved unit) and is, therefore, only another normal service.

TABLE 2

Sales of Year-round Residential Air-conditioning Systems

Year	No. of Systems
1946	0
1947	100
1948	200
1949	300
1950	1,400
1951	3,000
1952	10,000
1953	60,000
1954	120,000
1955	240,000
1956	360,000
1957	540,000
1958	700,000

The term "nonconserved air conditioning," as used in this paper, refers to equipment that passes condenser cooling water only once through the unit and then wastes it to the sewer. "Con-

served air conditioning" refers to installations in which a cooling tower or evaporative condenser is provided for cooling and recirculating the water. The quantity of water actually passing the condenser amounts to perhaps only 2 gpm per ton for the nonconserved equipment as against approximately 3 gpm for the conserved equipment. In the latter, however, the water is reused, with a makeup of approximately 2 per cent of 3 gpm, or 0.06 gpm. On the average, the water requirements during the maximum day will be 1,150 gpd per ton of nonconserved air conditioning, against 57 gpd per ton of conserved air conditioning. Available data indicate that about 10,000 cu ft of water per ton per season will be used with nonconserved equipment. Actual usage will, of course, vary with the weather. In a 122-day season, approximately 8.1 mil gal will be used per 1,000 tons of nonconserved equipment for each 1,000 degree-hours above 80°F.

The rise in consumer demand for air conditioning is indicated by Table 1. The figures include window and console models (up to 2 tons in capacity) which are air cooled and do not, in themselves, affect water demand. The full year-round air conditioning of homes with central station residential units is, however, of tremendous concern to the water utility. Past and projected sales of such units are shown in Table 2. They will range in capacity from 2 to 10 tons or more, and most of them will probably be water cooled. Air-cooled units are at present available up to 5-ton capacity, but they are usually uneconomical.

All important commercial buildings will ultimately have to be air conditioned for competitive reasons. It has been estimated (*1*) that, when 15 per

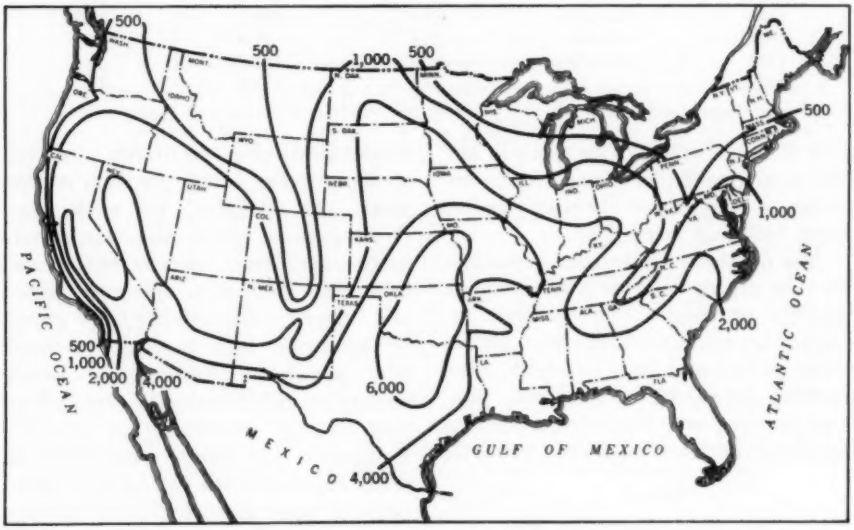


Fig. 1. Annual Cooling Requirements

Values are in "degree-hours" above 85°F (2).

TABLE 3

Air-conditioning Demand, Kansas City, Mo.

Year	Air Conditioning *tons*	Max.-Day Demand—*mil gal*		Air-conditioning Max.-Day Demand *% of total*
		Air Conditioning	Total (All Uses)	
1942	21,089	12.7	84.5	15.1
1943	21,721	13.1	73.7	17.8
1944	21,927	13.2	78.9	16.7
1945	22,092	13.3	85.6	15.6
1946	22,537	13.6	86.8	15.7
1947	24,324	14.7	95.1	15.4
1948	28,261	17.1	103.5	16.5
1949	35,316	21.4	101.5	21.0
1950	41,332	25.1	109.7	22.8
1951	42,000	25.4	97.8	26.0
1952	44,520	27.0	105.9	25.5
1953		29.0	129.8	22.5

cent of the desirable office space in any city is air conditioned, this service becomes a competitive necessity for all other buildings in the city.

The number of industries dependent to some degree upon air conditioning is steadily growing. The list now includes: ammunition, candy and confections, cereal and food products, film, leather, paper, pharmaceuticals, plastics, printing and lithography, textiles, tobacco, aircraft components, cameras, communications, electronics, optical goods, vitreous ware, precision equipment, blast furnaces, dye works, explosives, gases, heavy chemicals, rayon, rubber, antibiotics, bakeries, biologicals, breweries, distilleries, and meat packing. There is also another large group of industries, such as those involved with petroleum chemicals, in which cooling or refrigeration is required as part of the manufacturing process. Equipment for these applications is often identical with the basic components of large air-conditioning systems and is made by the same manufacturers.

TABLE 4

Load Factor, Kansas City, Mo.

Class of Service	Demand—*mgd*		Ratio
	Max. Day	Avg Day	
Entire system	104.7	59.0	1.78
Inside city	87.8	45.5	1.93
Suburban	11.0	8.8	1.25
Industrial (3 large industries)	5.9	4.6	1.28
Residential	30.7	18.7	1.64
Commercial (including air conditioning)	51.6	26.8	1.92
Nonconserved air conditioning	*24.2*	*4.3*	*5.62*
Other commercial	27.4	22.6	1.21

These statistics indicate without question that, at least in the next 10-year period, demands for water for air conditioning will increase very rapidly. If the water used is not conserved, the quantity required from the utility during the summer days will frequently overtax available facilities, even if steps are immediately taken to provide additional capacity. The effect will be greater in some portions of the United States—particularly the central states—than in others, depend-

ing on temperature and relative humidity (see Fig. 1).

The progressive effect of air-conditioning water requirements on the day of maximum demand at Kansas City, Mo., is indicated in Table 3. It will be seen that the maximum daily demand for air-conditioning water in 1953 was 22.5 per cent of the total maximum-day demand. Available data for Kansas City, Kan., indicate that only about 7 per cent of the maximum daily demand is for air conditioning. The mum-day to average-day demand at Kansas City, Mo., is shown in Table 4. As the maximum-day rate determines the size of the treatment plant and other facilities, these data indicate conclusively that nonconserved air-conditioning water is much more costly per gallon than water for other services. Calculations for Kansas City show that the cost of the former is 28 cents per 100 cu ft, as compared with approximately 10 cents for other commercial and industrial uses. If rate schedules reflected this differential, there would be no question of the economy of employing conservation equipment, except, perhaps, in older buildings, where the expense and inconvenience of installing the necessary plumbing might be excessive. The comparative economy of cooling-tower conservation versus nonconserved use of city water at 20 cents per 100 cu ft is shown in Table 5. At this price for water, conservation equipment is economical even for small installations. Such a charge, although not intended as a penalty, would have the same effect as an outright restric-

TABLE 5

*Annual Costs of Conserved and Nonconserved Air Conditioning**

Size of Unit *tons*	Cooling-Tower Installed $	Depreciation (10%) $	Maintenance (3%) $	Power for Fan and Pump† $	Makeup Water‡ $	Total Operating Cost $	Nonconserved Water§ $	Saving $
2	400	40	12	12	3	67	96	28
3	500	50	15	17	4	86	144	58
5	650	65	19	22	7	113	240	127
7½	800	80	24	30	11	145	360	215
10	1,000	100	30	35	14	179	480	301
15	1,450	145	43	50	22	260	720	460
20	1,850	185	55	65	29	334	960	626
25	2,200	220	66	85	36	407	1,200	793
35	2,500	250	75	100	50	475	1,680	1,205
50	2,800	280	84	125	72	561	2,400	1,839

* Assuming 1,500 hr of operation per year at temperatures varying from 78° to 95°F and averaging 85°F; water charge, 20 cents per 100 cu ft.
† Based on 2.5 cents per kilowatt-hour for 2–25-ton sizes, and 2 cents for 35- and 50-ton sizes.
‡ At 2 per cent of 3 gpm per ton.
§ At 2 gpm per ton.

comparable figure for Omaha, Neb., is 10.6 per cent. The lower percentages in these two cities reflect the fact that a considerable proportion of the system usage is attributable to large industrial customers. It is important to note, however, that, in all three cities, a reserve of several million gallons per day of plant and system capacity is required to meet the seasonal demand of nonconserved air conditioning.

The extreme seasonal character of nonconserved air conditioning is best indicated by the poor annual "load factor" of this service. The ratio of maxi-

tion or a regulation requiring conservation equipment.

If the source of supply is inadequate, the obvious solution is to prohibit nonconserved air conditioning by ordinance. A model ordinance of this type has been published as part of an AWWA committee report (*3*).

The establishment of a rate schedule to include proper charges for nonconserved air-conditioning service is politically difficult, especially when the existing schedule provides a decreasing charge as the quantity used increases. Likewise, a restrictive ordinance is unpopular, because "the free use of water is to be encouraged" and "the utility is in business to sell water." The alternative procedures—to restrict the use of water for lawn sprinkling on hot summer days or to raise large amounts of money to build more utility plant—are also politically inexpedient. The problem is too serious, however, to be ignored merely because the measures for dealing with it may be disagreeable.

References

1. *Air Conditioned America*, **3**:12:2, 5 (Sep. 1953).
2. *Industry & Power*, p. 65 (Dec. 1946).
3. Committee Report. Regulation of Air Conditioning and Other Refrigeration. *Jour. AWWA*, **42**: 1111 (Dec. 1950).

Editor's Note

There is great need for factual information from cities that have recognized the special characteristics of air-conditioning demand for water and have taken steps to adjust their rate structure to provide appropriate income for water used in air conditioning.

The Association's committee on the subject, headed by AWWA Vice-President F. C. Amsbary, has studied the returns received during 1953 from a questionnaire sent to cities with more than 10,000 population. Six cities have set up demand charges for air-conditioning water service when water conservation devices are not installed. Seven restrict water use without conservation in any size of installation. Eighteen have established restrictions upon nonconserved use—depending upon the tonnage rating of the installation. Eleven restrict water use on the basis of a variety of factors, such as outside temperature, total water requirements, or quantity of water discharged to the sewers.

The Association seriously needs the cooperation of its members in providing information concerning this important water demand.

Every reader of the Journal who is employed in a utility where a special regulation or rate has been set up to cover air-conditioning use of water should file a copy of the ordinance, regulation, or rule which is in effect in his utility.

Please cooperate!

Experience With Utility Radio

Joint Discussion

A joint discussion presented on Mar. 30, 1954, at the Southeastern Section Meeting, Greenville, S.C.

Alan McC. Johnstone

Supt., Electric & Water Div., Dept. of Public Utilities, Orangeburg, S.C.

THE Orangeburg, S.C., Dept. of Public Utilities, which furnishes both water and electricity to a population of approximately 15,000, has found radio communication invaluable in saving time and rendering faster and more efficient service. In January 1950 a 15-w mobile set was installed in the general-service truck that handles routine connections and minor emergency repairs. This radio unit was tied into the existing police department network, an arrangement that proved unsatisfactory because messages had to be transmitted by a police operator unfamiliar with the technical details of utility service. Therefore, in the spring of 1951, the utilities department decided to install its own radio system for the use of both the water and the electric division.

In establishing such a system, a number of factors require consideration. The equipment must be capable of operating in all weather and of covering the entire area served, which has a 12-mile radius. At Orangeburg, one main station was sufficient for the purpose, no relay transmitters being needed. A frequency band that will give a minimum of skip and direct interference has to be determined. The 152–174-mc band was found to be best suited for Orangeburg. In response to a query, the Southeastern Utilities Radio Group recommended 158.13 mc. The transmitter power output, height and location of antenna, and hours of operation all had to be decided upon

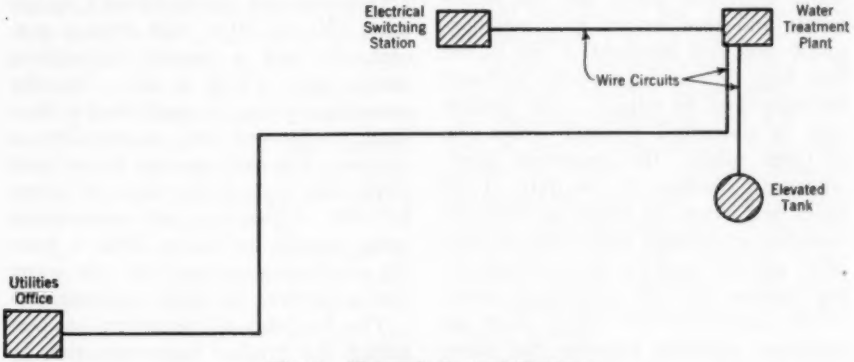


Fig. 1. Network Control Stations

The main transmitter, located at the elevated tank, can be remotely controlled from the water treatment plant (350 ft away), the switching station (350 ft from the treatment plant), or the utilities office (approximately ½ mile from the treatment plant).

before submitting formal application to the Federal Communications Commission in June 1951. An FCC license, for which there is no charge, was issued in September of that year.

Orders for equipment were placed in July and received by the end of August 1951. The equipment included one 50-w main station and six mobile units with 50-amp generators for the vehicles. The net has been operating 24 hr a day since Oct. 1, 1951.

The main station antenna is located on top of an elevated tank near the water treatment plant, and the transmitter and receiver are in a weatherproof steel box strapped to one of the tank legs, thus saving antenna lead and reducing loss in output. The station may be controlled remotely from one of three places: the treatment plant, where an operator is on duty at all times and where all telephone calls are switched after office hours; the utilities office uptown; and the electrical switching station near the treatment plant. These remote-control stations form an intercom network between the three points and have proved convenient on many occasions.

The elevation of the antenna is approximately 370 ft above mean sea level. The highest point in the area is at el 300, the terrain being mostly flat, with gently sloping hills. No dead spots have been found to date.

The initial cost of the main station and the six mobile units was approximately $6,200. The maintenance on this equipment, including labor and parts, has averaged $22.30 per month since its installation. At present there are eight mobile units. The department has retained a competent engineer to check and service this equipment twice a year, and one of its own engineers has been trained in first-echelon maintenance, which relieves most of the difficulties that occur. The improvement in service—and, consequently, in public relations—has been well worth the money and effort expended on the radio communication system.

Paul Weir

Gen. Mgr., Atlanta Water Works, Atlanta, Ga.

The Atlanta Water Works utilizes a modern radio communications system, including a 50-w FM base station operating on 156.13 mc (utility band), six remote-control units, 24 two-way (car-to-car and car-to-station) mobile units (50 and 60 w with 80-amp generators), and a central dispatching station open 24 hr a day. Standby emergency power is available for these units to prevent any interruption in service. The radio system, in use since 1949, has a present value of about $15,000. Operating and maintenance costs amount to about $900 a year. An electrician employed by the water works services all radio equipment.

The flexibility of the system has permitted the gradual interconnection by radio of a large portion (approximately 75 per cent) of the water works facilities, including production plants, maintenance and distribution shops, repumping stations, and commercial offices. Atlanta's $1,000,000-a-year distribution system expansion program was materially implemented by the use of radio, and the network has proved invaluable in emergencies. For instance, in November 1953, a 36-in. main break occurred at the central pumping station. Almost instantly the entire system was without water or on reduced pressure. Thousands of calls jammed the telephone circuits, but radio made it possible to direct operations satisfactorily. Incidentally, a complete radio dispatcher's manual has

been prepared to aid the utility's communications operators.

Radio has also demonstrated its usefulness in preventing emergencies from developing. Recently a gage at the dispatcher's office showed a pressure drop on a 16-in. main at 10:30 PM. A crew sent out to check this line, which was about 6 miles long, found a split fitting adjacent to a bridge abutment. The dispatcher referred to the plat card file and advised the crew foreman of the exact location of valves that would cut off the section over the bridge, thus forestalling a major break on a 175-psi pressure main which could easily have inundated a principal thoroughfare in a matter of minutes. It has been estimated that the radio station may have paid for itself in reducing the damage which either of the breaks mentioned might have caused. The system has rendered equally valuable service in other emergencies during the 5 years of its operation.

The two-way mobile radios are installed on medium and heavy maintenance and construction vehicles, fire hydrant and valve trucks, a patrol car, supervisors' cars, and commercial-office service vehicles. These transportation units average about 6,500 miles annually, and radio calls average about ten per unit per day. Three or four new radios are added every year at a cost of about $550 each.

The radio system is being continually adapted to meet new conditions and ever increasing needs. For example, when overhead wire extensions from the transmitter to the dispatcher's office half a mile away were found vulnerable to storm damage, the remote control stations, the transmitter, and the dispatcher's office were interconnected with underground conduit and cable to prevent interruption in service. The utility has also installed duplicate and emergency electrical equipment, so that the entire system may be operated on auxiliary generators whenever necessary.

It is planned to enlarge the station from the present 50-w unit to a 250-w unit and to raise the antenna tower from approximately 100 ft to 150 ft above ground elevation. All radio equipment is required to operate at peak efficiency and transmit clearly at all times. The radio service area has grown from 75 sq miles (with elevations varying from 750 to 1,100 ft) to more than 200 sq miles since 1950. The maximum distance from mobile unit to base station has increased from approximately 7 to 25 miles.

An emergency trailer now being built will carry duplicate power generators for electrical equipment and will contain a file of distribution valve and main plat cards, a canteen counter, first-aid kits, and tools. The two-way mobile radio unit that is to be installed in it will make this valuable trailer virtually a communications field office, in constant touch with the entire water supply system.

The utility has made a general study of the use of television in its operations. If funds were available, such equipment could be employed to advantage in steam-powered production plants, booster stations, elevated tanks, river intake control stations, treatment plants, and elsewhere.

Atlanta's radio system has saved hundreds of man-hours, thousands of miles of equipment travel, many thousands of dollars' worth of property damage, and even four or five lives in excavation cave-ins. It has also enabled the utility to render better service to consumers in day-to-day operations and has thus helped to improve public relations.

Progress of Stream Pollution Control in Indiana

By B. A. Poole and Ralph H. Holtje

A paper presented on Feb. 11, 1954, at the Indiana Section Meeting, Indianapolis, Ind., by B. A. Poole, Technical Secy., State Stream Pollution Control Board, Indianapolis, Ind., and Ralph H. Holtje, Chief, Industrial Waste Section, State Board of Health, Indianapolis, Ind.

STREAM pollution control activities have resulted in the restoration of more than 1,000 miles of streams in Indiana. Another 500 miles of streams are still suffering damage from sewage and industrial-waste discharge. Guiding, and often forcing, progress in this field is the Indiana Stream Pollution Control Board. Its general program, now in its eleventh year, is three pronged: [1] to prohibit and prevent new sources of pollution; [2] to locate and eliminate significant sources of pollution; and [3] to utilize the natural self-purification characteristics of streams without interfering with present uses and known future needs.

Protection of surface water supplies is essential. The future will demand more of surface than of ground water supplies for the reason that the former generally have a greater potential capacity. As cities expand, they surround their wells, and water production problems increase. Meanwhile the rising standard of living and industry's almost fantastic water needs put greater demands on those same wells. It behooves all concerned, then, to appreciate the value of improving and protecting surface water quality. Even today more than half of the 4,000,000 people of Indiana depend upon streams and lakes as a source of water. This number is increasing daily because of a general growth and shift of population toward the city and its environs.

Emphasis in cleaning streams was first directed toward municipal and institutional sewage treatment, principally because of the disease factor. The objective has now been broadened considerably to include pollution control for the protection of industrial water supplies, domestic animals, fish and wildlife, property values, and, more recently, aesthetic values.

Growth of Facilities

The first municipal plant in Indiana was constructed in 1903. The number rose to 10 by 1920 and to 30 by 1930. The depression of the early 1930's caused a lag in sewage plant construction, but, following the inauguration of the public works programs in 1933, the rate rose rapidly to a peak of sixteen new plants a year, in 1940. World War II held construction down except at new military and semimilitary installations. Since 1949, however, the picture has brightened and municipal plants are now being built at a rate of about five a year. Furthermore, the earlier plants have been receiving major additions and alterations at approxi-

mately the same rate. In 1953 Indiana had 102 municipal sewage treatment plants (Fig. 1).

In terms of money, this progress has meant an increasing public investment in intercepting sewers and sewage treatment facilities, totaling nearly $65,000,000 by Jan. 1, 1954. Approximately 75 per cent of the urban population of the fact that, in the fiscal year ending Jun. 30, 1953, the Indiana Stream Pollution Control Board reviewed and approved no less than 69 sets of plans and specifications for municipal sewers and sewage treatment plants.

There are 171 cities and towns in Indiana, representing a population of about 790,000, with at least a partial

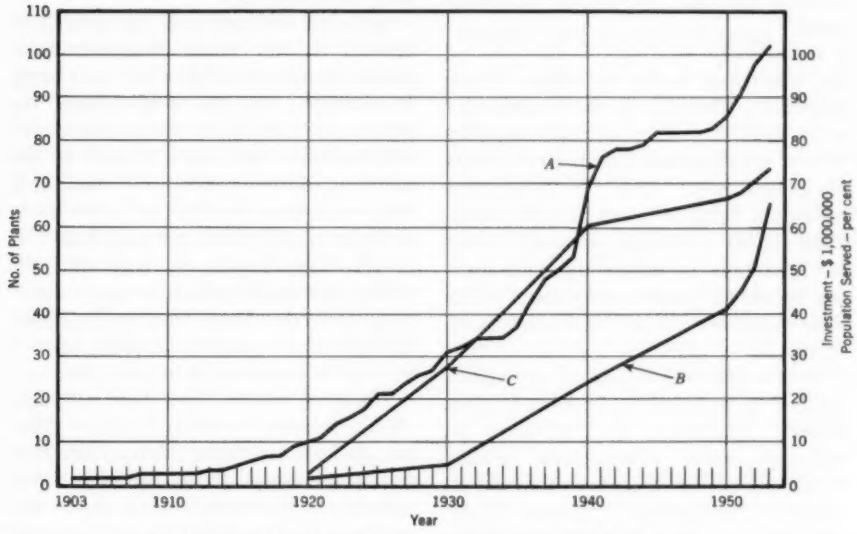


Fig. 1. Growth of Municipal Sewage Treatment in Indiana

A—*number of municipal sewage treatment plants;* B—*cumulative public investment in sewage treatment facilities;* C—*population served by municipal sewage treatment plants.*

Indiana now has sewers and sewage treatment, compared with 67 per cent in 1950.

New sewage treatment projects have been or are expected to be started in twenty cities in 1954, while major additions and alterations are under way in three others. An indication of a continued high-level rate of construction is sewer system but lacking sewage treatment. More than one-third of these places have completed engineering plans for adequate sewers and sewage treatment, leaving approximately 100 communities that have sewers of some sort but no program for sewage treatment. The pollution control board will not approve plans for major sewer exten-

sions or new outfall sewers unless adequate treatment is included as a part of the project.

Another 100 towns, with approximately 85,000 residents, have no sewer systems at all. These people have connections to public water supply systems and are likely to want sewer systems in the near future. The construction of such systems will not be approved without adequate provisions for treatment.

Admittedly, financing is the crux of the municipal water pollution control problem. The cost to the householder is reasonable. The average monthly service charge, based on twenty plants completed since 1947, is $1.65, the minimum being 90 cents and the maximum $2.90. Charges in small towns will generally be higher than the average because a greater percentage of the total investment is for the sewers themselves.

It is within the power of any incorporated municipality in Indiana to plan, finance, construct, and maintain an adequate sewer system and sewage treatment plant—if the will to do so exists. The Indiana Economic Council administers a $500,000 revolving fund, money from which is available without interest for the preparation of municipal plans. Loans must be repaid at the start of construction. Financing can be arranged by the sale of revenue bonds, amortized by a monthly service charge.

Industrial-Waste Treatment

Industrial wastes account for more than half of the water pollution still existing in the state. Acid formation in coal mines has been responsible for about 150 miles of rust-colored acid streams in southwestern counties. Approximately 50 per cent of the 150,000 tons of sulfuric acid annually discharged into streams was eliminated during a 5-year WPA mine-sealing program ending in 1941. The program has since been revived and is being carried on by the mine operators with the support of the Indiana Coal Producers Assn. Mine sealing and strip mine damming works will further reduce pollution from this source.

Industry did not have the benefit of federal aid for waste treatment programs during the 1930's and was badly handicapped by the depression. In recent years, however, national research organizations have been formed by the canning, dairy, paper, oil, steel, and other industries to find the answers to difficult waste treatment problems. It is also encouraging to note that the better informed industries are conferring with the State Stream Pollution Control Board before deciding upon a particular location for a new plant.

Cannery wastes have been an especially serious problem because they are produced at times when stream flow is low and temperatures are high. One solution is the storage of all waste water in lagoons. After several months' digestion, which reduces the strength of the wastes by perhaps 75 per cent, they are bled out into the receiving stream at times of high water in the spring. The number of such lagoons rose steadily from 83 in 1945 to 117 in 1952. The following year, however, many canneries were inactive, and only 95 canning-waste lagoons were used.

Since 1953 two canners have been screening and spraying tomato wastes on land seeded in forage crops. The advantage of this method lies in eliminating the discharge of wastes to streams. One large canner maintains

100 head of beef cattle on the screened tomato pulp and on the crops irrigated by the liquid portion of the wastes. Two Indiana milk plants are also planning to use the spray-irrigation method of disposal.

In the 7-year period 1947–53 alone, a total of 147 Indiana industries have provided new treatment facilities at a cost in excess of $23,000,000, an average of more than $3,000,000 per year. Nevertheless, a recent survey shows that approximately 200 industrial plants are still without adequate treatment facilities. There remains much work to be done, as the following incident illustrates: In June 1952 approximately 4,000 gal of plating solution containing 1½ tons of sodium cyanide was discharged into the Lafayette, Ind., sewer and finally into the Wabash River. This accident occurred in an electroplating plant where a foreman failed to close a drain line valve. A 3-mile long slug of toxic wastes moved down the Wabash River, and tons of fish were killed. Fifty miles downstream, the slug was no longer toxic to fish, but detectable traces of cyanide were observed 82 miles downstream. Ninety-seven miles downstream is the surface water supply intake of Terre Haute, Ind., serving more than 64,000 people. The supply was unaffected by the toxic slug, but the need for control was obvious. Accordingly, in January 1953, the State Stream Pollution Control Board, guided by comments of men in the plating industry, adopted and promulgated a regulation requiring the physical isolation of plating process and storage rooms from any sewer or stream.

Of the 210 cyanide-using industrial establishments in Indiana, 65 did not have to make plant changes to conform with the regulation. Another 65 have submitted plans for compliance and have obtained the approval of the pollution control board to proceed with construction; one-third of these have completed the work. The remaining industries are being visited. In two plants where new facilities have been installed, cyanide spills have since occurred, without causing fish kills and public health hazards.

Present and Future Problems

Although Indiana has an effective law and has made progress in controlling pollution, it still persists for a number of reasons. One is the fact that the public has awakened only recently to the real importance of clean waters to health and welfare. A second is the unfounded fear of committing political suicide by advocating the construction of a sewage utility that allegedly benefits people chiefly beyond the city limits. Third, the state has been unable to attract experienced, or even inexperienced, graduate sanitary, civil, and chemical engineers. It is competing with industry and higher governmental agencies at a disadvantage as far as beginning and maximum salaries are concerned. Skilled engineers must get the facts across to those making the decision to spend money. Where a cooperative approach is fruitless, experienced engineers are required to represent the state in obtaining, reporting, and interpreting facts presented in courts of law. Fourth, stalling tactics by officials and others have tied up some projects, and there are people who still dream of federal handouts and cheap depression construction. Lastly, construction has suffered a slowdown as a result of years of war.

Broadly speaking, the water works industry has solved most of its basic engineering and developmental problems. The somewhat younger and less stabilized fields of sewage and industrial-waste treatment have not yet reached that stage, but, even when all sewage and industrial wastes come to be treated, the water works man may still have his troubles. Demands for drinking and other legitimate water uses may not leave enough to dilute the treated sewage. Or if the quantity is sufficient, the quality may not be as high as desired.

As the water passes through distribution systems and out of sewage treatment plants in successive cities, there may be cumulative ill effects or possibly a buildup of new and different compounds. Synthetic detergents are now upsetting routine treatment in both water and sewage treatment plants. Each new organic compound that appears on the market seems to be more toxic than its predecessors. DDT, which has been ruled out of the dairy barn because of its accumulation in milk and then in humans, is giving ground to more powerful insecticides. The booming plastics field, dealing with phenolic compounds, may produce difficulties. Toxic algal concentrations may result from additional plant nutrients in streams. The present trend toward the universal use of sink garbage disposal units is daily increasing the raw-sewage pollution load. Radioactive wastes from atomic-energy installations may become a problem.

Questions of equity must also be faced: Should an industry be forced to spend millions for additional waste treatment units to accomplish what could be more efficiently done at the water treatment plant for merely thousands? Again, is it equitable for the water supply authority to demand that an industry reimburse it for the extra labor, equipment, and chemicals made necessary by industrial wastes?

Thus far, there are no final answers. These questions do, however, point up the fact that the fields of water treatment and sewage and waste treatment are inevitably being drawn closer and closer together by common problems. Long-range vision is needed in both upstream and downstream directions at every growing city.

Gas-burning Pump Engines

By K. H. Beard

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by K. H. Beard, Gen. Mgr., Del Este Water Co., Modesto, Calif.

THE Del Este Water Co. of California has, since 1946, been using internal-combustion pump engines burning natural gas. At present the company has twelve such engines, including nine four-cylinder and three six-cylinder models. One of the latter delivers more than 100 hp, while the other eleven produce 40–65 hp.

The average number of operating hours for these engines is 7,500 a year. They are completely serviced every 1,000 hr and are dismantled and overhauled once in 2 years. In addition, each machine is checked at least once a day—twice a day in summer—to be sure that the vibration, oil pressure, and temperature are normal and that the motors are running smoothly. Another means of checking available to the service man is the vacuum gage mounted on each motor. Any overloads show up immediately, and, as compression decreases and wear takes place in the cylinders, the gage reading reflects these conditions.

Major breakdowns of equipment have never been a serious problem. Only twice has it been necessary to shut down a motor in operation and replace the connecting-rod bearings, which, in both instances, were of the poured type, rather than the insert type. Investigation showed that the cracking of bearings could be prevented by proper regulation of the timing.

The cooling system must also be watched, particularly if the type of water being used has a fairly high mineral content. As there is a tendency toward lime incrustation within the cooling ports of the main block, the pH of the water is an important factor. The cooling system is of the enclosed type, using a heat exchanger and a thermostat. A small, open tank with a float valve keeps the water in the blocks and manifold at the proper level at all times. At first the water was circulated through the blocks without heat exchangers, but it was found that, in addition to the danger of cracked castings due to rapid cooling caused by accidental motor shutdowns, it was impossible to regulate the temperature for efficient operation. Damage to the equipment resulting from failure of the cooling system is prevented by the use of a solenoid switch to break the ignition system in the event of overheating. This switch serves a dual purpose, as it connects into the oil line and cuts off the ignition when the oil pressure gets dangerously low.

A conventional type of trickle-charged battery starter is used on eleven of the engines, as a generator would involve too great a power loss

penalty. The twelfth engine, owing to its large size, is started by an attached gasoline motor, which was believed far simpler to use than compressed-air equipment, the only other practical alternative.

Engine speed is controlled through a diaphragm type of pressure regulator that is energized by the water pressure on the main line. The regulator is connected to the carburetor butterfly valve by a combination of rod or cable and pulleys. The regulators have proved completely satisfactory and permit the maintenance of the desired pressure within remarkably narrow limits.

In the absence of elevated storage, it was never possible, with electric motors alone, to control the average pressure throughout the system. It is generally not feasible to start and stop an electric motor with less than a 15–20-psi pressure variation. As a result, a considerable pressure drop may occur at the end of extended lines. With the installation of natural-gas engines and the proper type of pressure regulator, this problem has been eliminated. Pressure surge is experienced only when the electric motors in remote areas cut in because of low pressure there. The fact that the gas engines are able to maintain pressure with little variation even at a low point prevents a particularly noticeable surge.

One of the principal advantages of gas engines is an uninterrupted fuel supply. Failure of the overhead electrical transmission lines, even if it lasts for hours, will not result in any substantial loss in pressure to consumers, because the gas-operated engines continue to function.

Sufficient data are not available to permit accurate cost determinations, but the following information will provide some indication of the relative economy of gas engines and electric motors. At an average head of 180 ft, the gas fuel cost per 1,000 cu ft of water pumped is 4.5 cents, and the electric power 8.4 cents. The cost of maintenance and operation is necessarily much higher for gas engines than for electric motors, however, amounting to approximately 50 per cent of the fuel cost for the former and only 10 per cent for the latter. The totals would then be 6.8 cents per 1,000 cu ft for gas and 9.2 cents for electricity.

Other factors to be considered are depreciation and initial cost. Although there is some doubt about the relative depreciation rates, 10 per cent per year for gas engines and 5 per cent for electric motors appear reasonable. For a 50-hp unit, the installed-cost differential in favor of the electric motor would be approximately $750. The importance of these items would, of course, vary in different plants.

Whether or not the ultimate cost of gas engines is greater than that of electric motors, the author would choose the former in view of the improved service to consumers made possible by this equipment.

Power for the Water Works System

By Glenn C. Boyer

A paper presented on Sep. 28, 1953, at the Missouri Section Meeting, Excelsior Springs, Mo., by Glenn C. Boyer, Cons. Engr., Carthage, Mo.

MISSOURI has approximately 350 cities and towns with public water supplies, each of which requires power in some form for pumping water into the distribution system. More than 65 per cent of these communities have a population of less than 2,500, and only 18 per cent have a population exceeding 5,000. By far the major source of power used for this purpose is electricity, owing to its availability and the low initial cost of motor drives for pumping units. But electric pumping is not the entire answer to the problem, because reliability of supply during emergencies is an equally important factor.

The power supply for any water works system must be a compromise between cost, availability, and reliability. Unfortunately, there is no simple correlation between these three requirements that is applicable to all installations. As a result, it is necessary to study each system individually, giving consideration to such matters as the quantity of water to be delivered; the pressure range to be maintained; the maximum, minimum, and average rates of flow; the effect of storage on pumping rates; the fire demands; the need for repumping occasioned by the topography of the area served; and the design of the distribution facilities to cope with the demand. This paper will discuss the variations in water works power demands, the reliability of different power sources, and the general method of economic analysis of such problems.

Variations in Power Demand

Many people fail to appreciate the extent of the variation in the power demands of water supply pumping facilities. In one community of approximately 4,000 population, on the minimum day, the pumps operated for 6½ hr at a rate varying from 460 to 550 gpm; on the maximum day, the pumps operated for 21½ hr at a rate of 420–890 gpm. During the first 7 months of the year (including both the minimum and the maximum day) the monthly average power requirements—for low- and high-service pumps, as well as for motors in the filtration plant—ranged from 1,580 to 2,280 kwhr per million gallons pumped into the distribution system. The variation in monthly power use was 40 per cent during this 7-month period. Unfortunately, although the plant has a record of variations in the quantity of water pumped and meters the total quantity of electricity used for pumping purposes, there are no data showing the relationship between changes in pumping rate and corresponding changes in power demand.

This type of metering arrangement is fairly typical of water works installa-

tions. To correlate power demand and pumping rate under such circumstances, it becomes necessary to make a series of calculations based upon the performance curves for the pump and the efficiency of the driving motor. Figure 1 shows this relationship for two types of pump commonly encountered in the water systems of towns with less than 5,000 population. One is a deep well pump delivering water directly into the system from a well, the other a centrifugal pump delivering water to the distribution system from a filter plant clear well. The former has a design rate of 200 gpm at a total head of 400 ft, while the latter is designed for 200 gpm at 200 ft.

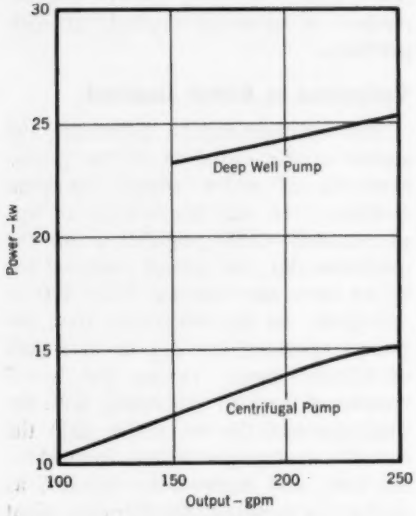


Fig. 1. Relation of Power to Pump Output

A constant-speed motor is assumed.

As Fig. 1 indicates, the electrical demand of the deep well pump at the design point is 24.3 kw, and that of the centrifugal pump is 14 kw. It is interesting that, in this instance, within the normal operating range there is practically a straight-line relationship between pumping rate and power input for both pumps. Whether such a relationship holds for other pump designs would have to be determined by developing the necessary curves.

Because of the lack of proper water and electrical metering facilities in most systems, little information concerning variations in water works power demand is available. There is a method, however, which permits the approximation of variations in electrical demand at a pumping installation when the total power used annually, the hours of operation of the pumps, and the peak load are known.

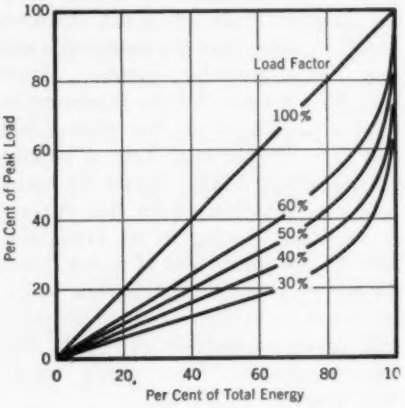


Fig. 2. Typical Energy-Load Curves

This relationship between peak load, energy generation, and load factor is based on studies of electrical production by generating stations. It is believed that these curves apply to water pumping loads with an error of less than 10 per cent.

For example, assume that a motor-driven deep well pump operates 3,000

hr a year, uses 120,000 kwhr, and has a peak load of 100 kw. The average load is 120,000 ÷ 3,000, or 40 kw, and the load factor (ratio of average to peak load) is 40 per cent.

Studies of electrical production by generating stations show a relationship between peak load, energy generation, and load factor as in Fig. 2. On the assumption that this relationship also applies to the electrical requirements of a pump, a 40 per cent load factor would mean that 50 per cent of the energy (60,000 kwhr in this example) was used by loads of 20 kw or less, and 80 per cent of the energy (96,000 kwhr) by loads of 36 kw or less.

It may be objected that power plant generating data cannot be applied to motor-driven water works pumps. In the author's opinion, however, this method of analysis is the best available. It is believed that these curves can be applied to water pumping loads with an error of less than 10 per cent.

Reliability of Power Sources

A reliable power supply is vital to the proper operation of a water works system. Adequate power must be furnished continuously or with only occasional, momentary interruptions that do not affect the system's ability to meet all demands.

There are three possible sources of power for water pumping: electrical energy for motor drives, internal-combustion engines, and steam engines or turbines. All have advantages and disadvantages. Purchased electrical energy, which is usually the cheapest power source for the small water system, requires a minimum investment in equipment but has a rather poor record of reliability, particularly if the community is served by a transmission line in an area subjected to lightning or ice storms. The author lived for a number of years in a Missouri community where electrical interruptions were so common that electric clocks were useless.

In a certain western city, supplied from a modern transmission system controlled by the latest carrier current relaying and protective facilities, lightning once hit the transmission line and left a 4,000-sq mile area without electricity for 18 min. To add to the confusion, the pow r company's communication system also failed, and the operating crews swamped the long-distance telephone circuits in the region trying to find out what had happened. There is still truth in the famous remark by Steinmetz that "lightning seldom strikes twice in the same spot because there generally isn't anything to hit the second time." Because of the possibility of failure in time of emergency, the National Board of Fire Underwriters is constantly reminding municipalities of the dangers inherent in relying entirely on an electrical transmission line for their water works power supply.

Many plants use internal-combustion engine pump drives for emergency and standby service. These are often gasoline engines, although oil-burning and dual-fuel diesels are also employed. At present 47 Missouri municipalities operate diesel-electric generating plants to supply the respective communities with electrical energy. In practically all of these cities, the water works is immediately adjacent to the power plant and is assured of a reliable supply of electricity for pumping. Other communities should give consideration to maintaining an emergency power supply such as a gasoline or diesel engine. The cost of standby facilities is often justified by the im-

provement in the reliability of the power supply.

The type of internal-combustion engine selected must, of course, meet the needs of the particular installation. Such factors as horsepower requirements, space limitations, available fuels, demands for continuity of service, and operator's preference should be taken into account. There was a time when much stress was placed upon the relative merits of the two-stroke and the four-stroke cycle engine, but experience has shown that either is acceptable, and both are used widely in the United States. Supercharging of four-stroke cycle engines has come into greater prominence since World War II. A supercharged engine produces 1½–2 times as much horsepower from a given cylinder at the same rotative speed as its nonsupercharged counterpart. The high cost of fuel oil in recent years has accelerated the application of the dual-fuel engine burning both gas and oil. This, in turn, has intensified development work on the high-pressure spark-ignition gas engine. The reliability of internal-combustion engines, both gasoline and diesel, has become so well established that there is no longer any question about their ability to perform satisfactorily, given intelligent maintenance and operation.

Steam power is feasible for water pumping only in large installations, owing to the high investment cost and the comparatively large operating staff necessary. Of the four cities in Missouri with steam-powered pumping, two employ it on a standby basis and the other two utilize it for only a portion of their service. Ten additional Missouri communities operate steam-electric generating stations for supplying electrical energy within their confines. In most of these cities, the water works is adjacent to the power plant.

Method of Economic Analysis

Pumping costs for a water works include four elements: energy, maintenance, operation, and fixed charges on investment. The energy cost may be the cost of electrical energy purchased, petroleum products consumed in an internal-combustion engine, coal burned in a steam station, or any combination of these. Maintenance and operation include the labor and materials necessary for utilizing the energy-producing and pumping equipment and keeping it in working order. The fixed charges include interest and either principal payments or depreciation charges on the capital investment in the energy-producing and pumping facilities. When comparing the costs of pumping with different energy sources, care should be taken to see that all have equal reliability. Otherwise, the economic study will not provide a true comparison.

The quantity of energy required, whatever the type, can be calculated once the amount of water to be pumped, the pumping head, the flow rates, and the efficiencies of pumps and prime movers are known. When combinations of energy sources are under consideration, the determination of the percentage of total energy supplied by each source can be estimated with the aid of the curves in Fig. 2. The energy source showing the lowest unit cost can be used for the base load, with the peaks carried by the high-cost power source. Power supply problems of water works plants are not simple, but they can be solved in such a way as to provide both economy and reliability.

Combating Pipeline Growths by Maintaining Chlorine Residuals Throughout a Distribution System

By George Y. Blair

A paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by George Y. Blair, Asst. Engr., Water-Gas-Sewer Div., Palo Alto, Calif.

IN February 1951 Palo Alto, Calif., began the chlorination of all water entering its distribution system, employing individual chlorination units at each of the city's eight well sites and at two connections with transmission lines from San Francisco. This measure was adopted in response to increasing complaints of "red water" and foul odors, conditions that arose shortly after the introduction of the supplementary supply from San Francisco in 1938 and became progressively worse over the years despite a main-flushing program.

A number of utilities in the California coastal area have been plagued by red water troubles due to *Crenothrix*, a genus of iron bacteria (*1, 2*). It had been reported that some of the San Francisco transmission lines were infested by this organism. If that were so, the Palo Alto system might also have become infested. Iron bacteria assimilate oxygen and partially oxidized iron, complete the oxidation reaction, and produce red water upon being sloughed off of pipe walls. When such bacterial activity is going on, the water can become so depleted of its dissolved oxygen that anaerobic conditions may result. Such a situation was found to exist in the Palo Alto distribution system, principally in dead ends and other areas of low flow. These so-called zones of degradation were characterized by little or no dissolved oxygen, foul odors, and *Crenothrix* colonies. Tests made by the state health department at the city's request indicated the presence of *Crenothrix* in a majority of the Palo Alto wells, the water supply from San Francisco, and many points in the distribution system itself.

Chlorination Program

It was decided that chlorination was the most economical and practical means of combating the effects of *Crenothrix*. The necessary equipment was purchased and installed in 1950. Before actually starting chlorination, however, exhaustive dissolved-oxygen tests were made, so that the results could be used to measure any subsequent improvement. These tests, approximately 200 of which were carried out in all known areas of degradation throughout the distribution system and at all sources of supply, showed a dissolved-oxygen content ranging from 0 ppm to 4.0 ppm, the average being 1.9 ppm, substantially less than the 6.5-

ppm average found at the various points of entry into the system.

Another step taken in advance of chlorination was to enlist the aid of the local newspaper in notifying consumers of the reasons for the program, the results expected, and the tastes and odors that would be present during its early stages. It is believed that this precaution helped greatly to keep the number of initial complaints to a minimum.

The city planned to attempt to maintain, from the start, a 1.0-ppm free chlorine residual in the distribution reservoirs, and at the transmission line connections, in order to hasten the action of the chlorine on the bacterial colonies. It was expected that, as the chlorine passed through the distribution system, its reaction with the bacterial products would cause tastes and odors to become more and more evident. It is worthy of note, however, that, in those areas of the system where the free chlorine residual was on the order of 0.4 ppm, no objectionable tastes or odors occurred, although they were quite prevalent where the residual was less than 0.2 ppm.

In an effort to carry a 1.0-ppm free chlorine residual throughout the whole distribution system, a new flushing program was undertaken. Systematically covering one area after another, working from the various points of entry into the system toward the extremities, it required approximately 2 weeks to flush out the system completely. This procedure was repeated for a period of 3 months. During the first month of chlorination, great quantities of tubercles and slime organisms were to be found issuing from the fire hydrants when flushed.

In that same month, dissolved-oxygen and free chlorine residual determinations made at selected control points indicated that the anticipated results were being obtained. The average oxygen demand fell from 4.6 ppm to 0.5 ppm. During the early phases, the average free chlorine residual in the system was 0.2 ppm, varying from a maximum of 1.0 ppm in the reservoir effluent to zero in the distribution system extremities. As the flushing program proceeded, the average system residual rose to 0.6 ppm, with 0.2 ppm at the extremities.

Results Achieved

After 3 months red water complaints stopped completely, but some reports of tastes and odors continued to be received, all of them from consumers whose service lines were so infested with *Crenothrix* that the entire free chlorine residual available in the distribution mains was being absorbed. In time this condition cleared up, although occasional taste and odor complaints are still being received. In practically all such instances, it is found that the offense occurs in the morning, after the water has lain in the pipes overnight and all the free chlorine has been consumed. After this water and its chloro products have been expelled from the lines, the tastes and odors vanish, only to recur when consumer use drops off and the free chlorine residual again disappears. It often happens that a service line sample will show no free residual chlorine when the distribution line sample has as much as 0.6 ppm.

The chlorine demand in the system has steadily decreased—except during the spring of 1952—from an initial average of 0.75 ppm to an average of 0.15 ppm in 1953. In the spring of 1952 the demand rose to 0.75 ppm but dropped off within 2 months as a re-

sult of additional flushing. This temporary increase was attributed to the fact that, in the summer of 1951, 3 months after chlorination had started, the flushing program was stopped because it was felt that the distribution system had been sufficiently cleaned.

Early in the spring of 1952 renewed complaints began to be received regarding red water. As this condition was not accompanied by tastes and odors, it was conjectured that the trouble was not biological in origin but rather an effect of the chemical composition of the water. Further investigation traced the difficulty to three wells with combined iron and manganese contents ranging from 0.3 to 0.5 ppm. The application of chlorine and the increased dissolved-oxygen content of the water brought about the complete oxidation and eventual precipitation of the iron and manganese. Owing to the relatively short reservoir detention period (3–8 hr), precipitation did not occur until the water was in the distribution system. During the winter months, when the water demand and flow velocities were low, the precipitates were deposited in the system extremities and distribution loops. In the spring, as the demand increased and San Francisco water (not used in the winter) was introduced into the mains, distribution flows rose in velocity and, in many instances, changed direction, thereby disturbing the deposits and bringing them up into the moving stream, the inevitable result being red water.

It was found possible to eliminate the problem by flushing the system, concentrating on the areas known to be supplied by the three offending wells. In the spring of 1953 red water complaints were less frequent because the trouble had been anticipated and spot flushing programs were initiated early.

The effectiveness of the chlorination and flushing programs is indicated by the fact that, in the year 1952–53, a total of 152 water quality complaints were received, compared with 1,256 during the year 1950–51. This amounts to a reduction of more than 1,100 in just 2 years.

Conclusions

Experience at Palo Alto shows that:

1. Free residual chlorination is an effective means of combating *Crenothrix* infestation, as evidenced by the improvement in water quality and an 88 per cent reduction in complaints in 2 years.

2. A free chlorine residual can be maintained throughout an extensive distribution system (Palo Alto serves 13,000 consumers through 126 miles of distribution mains).

3. The chlorine demand of the distribution system diminishes with time until a stable point is reached.

4. Even though the extent of *Crenothrix* kill in the distribution mains is satisfactory, tastes and odors may still be present at the consumer's tap, because of the additional time required to effect complete kill in the service lines.

References

1. Derby, R. L. Control of Slime Growths in Transmission Lines. *Jour. AWWA*, **39**:1107 (Nov. 1947).
2. Wilson, Carl, et al. Control of Growths in California Distribution Systems. *Jour. AWWA*, **42**:849 (Sep. 1950).

Survey of Recent Canadian Water Treatment Installations

By A. E. Berry and G. M. Galimberti

A paper presented on Apr. 14, 1954, at the Canadian Section Meeting, Toronto, Ont., by A. E. Berry, Director, and G. M. Galimberti, Sr. San. Engr., San Eng. Div., Provincial Dept. of Health, Toronto, Ont.

THE postwar expansion of water works systems in Canada has been a major achievement. This development was made necessary by the great increase in urban population—from 12,000,000 to 15,000,000—and the vast industrial growth since 1945. The water works expansion program is by no means over, and the continuing high rate of growth can be expected to result in more new distribution systems and treatment plants and additions to existing units.

At present there are 1,550 public water works systems in Canada, of which 710 are in Quebec Province and 400 in Ontario. These municipal plants serve well over 9,000,000 people, or nearly 65 per cent of all persons living in either urban or rural areas in Canada. Extensions of mains to serve new subdivisions in the fringe areas of cities and towns have been especially rapid. In 1953, in Ontario, about 86 per cent of the $24,500,000 worth of water works projects approved by the Canadian Dept. of Health was for system extensions, and 14 per cent for treatment plants.

Out of 1,550 water systems, only 217 (Table 1) have filtration plants. Although nearly 1,200 municipalities use surface waters, many of these supplies are well protected, and chlorination is the only treatment employed. Canada is fortunate in having so many large bodies of water that can be used successfully for domestic consumption.

In recent years a substantial number of new water treatment plants have been built and many additions made to existing ones. These works have been designed by a number of engineers to purify different kinds of water throughout Canada. An analysis of these more recent works should reveal current Canadian practice and trends in water treatment. Information on many plants built since 1949 has been tabulated and examined. The total number of filtration plants has risen by 40—more than 22 per cent—in the last 5 years. Thus, this period can be considered one in which considerable activity has occurred. In addition to filter plants, some of these new projects involve softening, disinfection, taste control, fluoridation, or other measures associated with water purification or quality adjustment.

Information on water treatment plants in operation in Canada is summarized by provinces in Table 1. Table 2 lists treatment plants constructed since 1949, along with such general information as population served, type of plant, cost, and capacity. Details of treatment facilities

at these plants are shown in Tables 3 and 4.

Nearly all water filtration plants now being built in Canada use the gravity type of rapid sand filter,* although a few pressure units have been constructed, either for small populations or because of special conditions. Table 5 lists 36 rapid sand plants (including new plants and additions to existing ones) which have been analyzed in this paper in order to determine current Canadian practice and trends. The fact that the plants were designed by a number of different engineers lends interest to the results. The sources of supply have varied widely, and costs depend a good deal on local conditions.

As costs are difficult to compare with any great degree of equity, such figures are given for general information only. In Table 6, the costs of certain new rapid sand plants have been converted to a unit capacity basis (dollars per million Imperial gallons per day, using a rate of 2 US gallons per minute per square foot of sand surface). It will be noted from Table 2 that the total expenditures include a number of different items, a further reason why costs cannot be compared, except in general terms.

For plants with capacities of 1 mgd or less, the unit capacity cost varied from $143,000 to $500,000, averaging $284,000; the cost per capita averaged $42.80. For plants of 1–5 mgd, the unit capacity cost ranged from $115,300 to $400,000, averaging $224,000, and the cost per capita averaged $38.90. For plants larger than 5 mgd, the unit capacity cost averaged $157,000, the per capita cost $38.75.

* Hereafter the term "rapid sand" refers to the gravity type only.

Mixing and Sedimentation

Table 3 records the methods of mixing and sedimentation used ahead of the filters. The retention periods in mixing chambers show no great variation, ranging from 20 to 60 min, with most being close to 30 min. Thirteen plants use spiral-flow and eight, mechanical mixing. These two methods are well distributed. Baffles are used in four plants, one in Alberta and the others in Quebec Province. Solids-contact process units (referred to as "upflow basins" in Table 3) are in use in seven plants.

In the sedimentation tanks the detention times are mostly between 2 and 4 hr, with eighteen nearer the former and nine nearer the latter. All are single-story tanks, and the shapes differ widely. Sedimentation tanks are cleaned manually in all new installations except at Renfrew and Scarborough, Ont. Automatic sludge removal, controlled by a time clock operating on a 5-min cycle, has been provided on the solids-contact installations at Swift Current and Regina, Sask.

Filter Design Data

The general figure of 2 gpm (US) per square foot has been used in all filter designs, with the exception of three plants in Quebec where the rate is 1 gpm. The choice of these conservative design rates provides an added factor of safety, if the plants should be required to take increased loads before they can be expanded or to handle high loadings for short intervals.

Sand with an effective size of 0.4–0.5 mm is used in eighteen plants, anthracite coal with an effective size of 0.6–0.8 mm being used in eleven

others. The depth of sand or anthracite varies from 24 to 30 in. in these plants. A combination of anthracite and sand is used at four plants, with 12 in. of the former capping 18 in. of sand.

The gravel depths range from 12 to 26 in., with 66 per cent of the plants reporting either 15 or 18 in. All gravel beds are of the usual type of graded gravel.

A variety of underdrain systems have been installed, cast-iron strainers or Miller blocks being equally favored in 65 per cent of the installations. Other types used include Wagner blocks, Wheeler bottoms, and, in one instance, Aloxite blocks. Three small plants in Manitoba have installed homemade concrete block underdrains. The Miller blocks—developed by a Canadian, George Miller—have been installed in 32 plants in the Dominion since 1947.

The new plants are uniformly using low-head centrifugal pumps for backwashing, as they occupy little space, are generally cheaper in initial cost, and have the additional advantage of producing a constant head, while that derived from a tank or standpipe varies. Wash water rise rates vary from 16 to 24 ipm, with most plants using 18 or 24 ipm. Surface wash equipment, such as Palmer sweeps or Baylis or Hankin fixed jets, has been installed in practically every plant. It is now recognized that one of the best investments in efficiency is the installation of a well designed surface wash system in each filter. Steel wash troughs are favored in most plants although there are some reinforced concrete trough installations. Filter troughs are generally placed 6–10 in. above the surface of the filtering material, when the latter is expanded to a maximum.

Hydraulic-cylinder and direct-acting valves are in general use on filter influents, effluents, wash water supplies, wash water waste, and rewash lines. There are a few manual installations in the smaller plants. Although mechanical, pneumatic, and electrical filter gages are used, the majority of the installations employ the first. Only a few wash water controllers and sand expansion gages have been installed.

Chlorination

Chlorination is provided both before and after filtration in twenty of the plants reporting. The installation of chlorine dioxide treatment has come to the fore at new water works located in industrial areas. New developments include the introduction of chlorine residual recorders and the installation of a device for automatically proportioning a visible vacuum chlorinator. This unit electronically controls a chlorinator from one or more differential-producing devices, such as a venturi tube. An installation of considerable interest in the field of water works chlorination was made in the addition to the Brantford, Ont., plant. The treatments of superchlorination, dechlorination, and chloramination are now carried out automatically by four chlorinators, two sulfur dioxide feeders, and two ammoniators. In addition, there are residual recorders and equipment for handling and storing ton cylinders of chlorine.

Softening

Water softening has not been practiced to a great extent in municipal plants in Canada, its application being limited, chiefly, to industrial units.

Consequently, there has been no noteworthy development in Canadian municipal softening plants in recent years.

Summary and Conclusions

The designs of water treatment plants built in Canada in recent years have generally incorporated conservative, well established practices. There has been no tendency to discard proved methods until newer measures have been assured of success. It is apparent that designers have been eager to adopt mechanical devices and equipment for the preparation and filtration of the water. There have been many refinements in plant design, all tending toward the objective of effective treatment combined with ease of operation and control. All of these activities have assured Canadian municipalities of plants capable of delivering safe water of high quality.

Looking at these plants in closer perspective, it will be seen that developments are taking place from year to year, and each new plant, especially if it is relatively large and unhampered by economic restraints, usually incorporates the latest methods and devices. Cost restrictions are often barriers that the designer must struggle to overcome. In evaluating the cost data presented in this paper, it should be kept in mind that most of the new plants recently constructed are of moderate size. Projects at the larger works have usually been additions to existing units rather than complete new plants. Using the plants of Scarborough, Kingston, and New Toronto, Ont., and recognizing these limitations, it is seen that the cost averages $126,000 per million Imperial gallons per day of designed capacity. The cost per capita for these plants is somewhat misleading in that they are intended, in part, to serve populations outside the municipal boundaries. The average cost for plants of 1–5-mgd capacity is $224,000 per 1 mgd; for plants of less than 1-mgd capacity, the corresponding figure is $284,000.

Preparation of water for filtration is accomplished in different ways, with spiral flow, mechanical mixing, and precipitated solids. Solids-contact units are fairly evenly distributed. Alum is in use in nearly all these plants. Silica is not applied much, but it has been found beneficial in some plants and greater use can be expected. Gravimetric feeders are increasing in application. No major change has been adopted in sedimentation tank design or methods of cleaning.

In filter design, most recent changes have been in the underdrain systems. Operation at high rates has not been provided for in the designs, but is employed for short periods of peak demand. Both sand and anthracite coal are common.

Progress in architectural features and convenience of operation has been good. Even the best plants, however, can be operated efficiently only by well trained, conscientious employees.

Canadian water treatment plants are improving with each new design, and it can be expected that advantage will be taken of new developments in equipment and devices conducive to the best results, obtained under the easiest methods of control.

TABLE 1

Municipal Water Treatment Plants *

Province	No. of Treatment Plants						
	Rapid Sand Filters	Slow Sand Filters	Pressure Filters	Unspecified	Total (1954)	Increase Since 1949	Changes or Additions (1949–54)
Alberta	7			25	32	21	
British Columbia	1	0	1	0	2	0	0
Manitoba	7	0	3	0	10	4	1
New Brunswick	3	0	0	0	3	0	0
Newfoundland	0	0	0	0	0	0	0
Nova Scotia	1	0	0	1	2	0	0
Ontario	39	5	38	1	80†	9	15
Prince Edward Island	0	0	0	0	0	0	0
Quebec	50	4	9	11	74	3	5
Saskatchewan	5	0	7	2	14	3	0

* Plants using chlorination only are not included.
† Three plants employ more than one type of filtration.

TABLE 2

General Information on Treatment Plants Constructed 1949–54

Province and Municipality	Pop.	Type of Plant Installed *	Cost $	Cost Includes*	Added Capacity *mgd* *
Alberta					
Camrose	5,300	upflow basin, rapid sand filters			0.3
Castor	1,200	rapid sand filters	40,000	some extras	0.2
Red Deer	8,000	cold lime-soda softening, upflow basins, rapid sand filters	410,000	river intake, raw-water & high-lift pumps	3.6
Manitoba					
Brandon	22,000	change from pressure to rapid sand filters & cold lime-soda softening			
Minnedosa	2,300	rapid sand filters	56,000	200,000-gal storage, town pumphouse, filters & building	0.2
Morden	1,800†	pressure filters	8,000	filters, but not building or storage tank	0.12
Morris	1,000	rapid sand filters	21,000	28,000-gal clear well	0.14
Souris	1,500	rapid sand filters	36,000	50,000-gal storage	0.14

* Capacity in Imperial gallons.
† Design population, 2,500.

TABLE 2—*General Information on Treatment Plants Constructed 1949–54 (contd.)*

Province and Municipality	Pop.	Type of Plant Installed *	Cost $	Cost Includes*	Added Capacity *mgd* *
Ontario					
Alexandria	2,500	rapid sand filters	158,400	intake pipe, filtration plant, pumping station	0.58
Beamsville	1,925	rapid sand filters	140,000	filtration plant, but not intake	0.4
Beaverton	980	pressure filters	30,000	sedimentation basin, 2 filters, but not intake	0.36
Brantford	45,000	2.5-mgd rapid sand filter addition	300,000	chemical building for central control of chlorination	2.5
Bronte	1,100	pressure filters	82,400	intake pump & filter house, reservoir, equipment	0.14
Burlington	8,500	2-mgd rapid sand filter addition	220,000	additional mixing & settling capacity	2.0
Delhi	1,500	2 pressure filters	70,000	intake pump & filter house, mixing & settling basins, equipment	0.46
Hawkesbury	8,000	upflow basin, rapid sand filters	476,500	upflow basin and filtration plant installation	3.0
Kingston	43,000	rapid sand filters	957,500	filtration plant, intake, pumping station improvements	10.0
New Toronto	20,000	15-mgd rapid sand filter addition to pressure filter plant	2,000,000	filtration plant addition	15.0
Oshawa	50,000	5-mgd rapid sand filter addition	600,000	filtration plant addition	5.0
Peterborough	45,000	2-mgd rapid sand filter addition	303,000	filtration plant addition	2.0
Picton	4,500	1-mgd rapid sand filter addition	130,000	filtration plant addition	1.0
Port Credit	4,500	1.4-mgd rapid sand filters to replace slow sand filters	104,000	filtration plant change	1.4
Port Hope	6,400	1.25-mgd rapid sand filters to replace slow sand filters	100,000	filtration plant change	1.25
Port Rowan	750	Pressure filters	35,000		1.2
Renfrew	8,000	2-mgd rapid sand filter addition to pressure filter plant	300,000	filtration plant addition	2.0
Scarborough Twp.	80,000	10-mgd rapid sand filter addition to pressure filter plant	1,500,000	filtration plant addition	10.0

* Capacity in Imperial gallons.

TABLE 2—*General Information on Treatment Plants Constructed 1949–54 (contd.)*

Province and Municipality	Pop.	Type of Plant Installed *	Cost $	Cost Includes*	Added Capacity *mgd* *
Ontario (contd.)					
Toronto Twp.	20,000	rapid sand filters	357,500	filtration plant	2.5
Trenton	15,000	rapid sand filters	400,000	filtration plant	1.0
Vineland	1,500	rapid sand filters	98,000	filtration plant, intake	0.4
Wallaceburg	7,500	1.25-mgd addition	55,000	filtration plant addition	1.25
Windsor	165,000	21-mgd rapid sand filter addition	800,000	filtration plant addition	21.0
Quebec					
Asbestos	8,200	rapid sand filters			
Barville		rapid sand filters			
Crabtree Mills	1,200	rapid sand filters	100,000	family living quarters, road, landscaping	0.2
L'Abord-à-Plouffe	5,000	rapid sand filters	100,000	filtration plant	0.3
L'Assomption	3,000	rapid sand filters	120,000	filtration plant	0.39
Murdochville		rapid sand filters			
Pont Viau	11,500	rapid sand filters	300,000	filtration plant	0.67
Sillery	10,000	rapid sand filters			
Saskatchewan					
Portage la Prairie	7,500	upflow basin, 3 rapid sand filters	245,000	revamping of low-lift pump-house, installation of new high-lift pump	0.83
Regina	75,000	rapid sand filters	1,800,000	design for final capacity of 24 mgd	6.0
Swift Current	8,000	upflow basin, 3 rapid sand filters	165,000	pretreatment facilities, additional filters, automatic chlorinator, automatic fluoridator	0.8
Armed Services Installations					
Alberta					
Camp Wainwright	35,000	rapid sand filters			3.0
Manitoba					
Ft. Churchill	3,000	upflow basin, pressure filters			0.5
Rivers		pressure filters			0.43
Quebec					
St. Hubert	3,500	rapid sand filters			0.5

* Capacity in Imperial gallons.

TABLE 3

Mixing, Settling, and Chlorination Features of 1949–54 Plants

Province and Municipality	Mixing				Sedimentation			Chlorination		
	Detention Period *min*	Type of Mixing	Mechanical Stirring	Rapid Mix	Tank Size *cu ft*	Detention Period *min*	Cleaning Arrangements	Point of Application	Type of Machine	Automatic Features
Alberta										
Camrose	upflow basin: 13-ft diam., 11-ft depth							raw water	vacuum	semiautomatic
Castor	45	baffles	no	no	2,244	240	drain, flushing	mixing well	pressure	none
Red Deer	60	upflow basin						before softener & filters	vacuum	from orifice in raw-water line
Manitoba										
Brandon										
Minnedosa	30	spiral flow	no	no	1,353*	120	drain to river	plant effluent	vacuum (hypochlorinator)	with service pump
Morden	no	no	no	no	no	no	no	plant effluent	vacuum (hypochlorinator)	with service pump
Morris	30	spiral flow	no	no	900*	120	drain to river	plant effluent	vacuum (hypochlorinator)	none
Souris	30	spiral flow	no	no	1,353*	120	drain to river	plant effluent	vacuum (hypochlorinator)	with service pump

* Two units.

TABLE 3—*Mixing, Settling, and Chlorination Features of 1949–54 Plants (contd.)*

Province and Municipality	Mixing				Sedimentation			Chlorination		
	Detention Period *min*	Type of Mixing	Mechanical Stirring	Rapid Mix	Tank Size *cu ft*	Detention Period *min*	Cleaning Arrangements	Point of Application	Type of Machine	Automatic Features
Ontario										
Alexandria	32	spiral flow	in first chamber	no	7,680*	220	drain	raw & treated water	pressure	
Beamsville	27.5	mechanical	yes	yes	3,075*	140	drain	raw & settled water	vacuum	none
Beaverton					7,040	150	drain	settled water	vacuum	
Brantford	37	spiral flow			4,500	190	drain	raw & filtered water	§	residual recorders; automatic
Bronte	no	no	no	no	no	no	no	plant effluent	vacuum	with service pump
Burlington	35	spiral flow			3,400	190	drain	raw & filtered water	vacuum	none
Delhi	54				600	170		settled water	vacuum	none
Hawkesbury	upflow basin: 39 × 39 ft, 3-mgd capacity									
Kingston	30	spiral flow	no	no	70,675*	130	flushing	raw & treated water	vacuum solution feeder	proportional flow
New Toronto	33	mechanical	paddles		100,000†	190	drain	raw & filtered water	vacuum (ClO_2)	proportional flow
Oshawa	27	spiral flow			66,100	120	flushing through drain			
Peterboro	25	turbulent flow		no	50,000‡	360	drain, flushing	plant effluent	vacuum	proportional flow
Picton	20	spiral flow			12,600*	120	drain			

* Two units. † Three units. ‡ Four units.
§ Four vacuum chlorinators, two SO_2 feeders (for dechlorination), two chloramine feeders.

TABLE 3—*Mixing, Settling, and Chlorination Features of 1949–54 Plants (contd.)*

Province and Municipality	Mixing				Sedimentation			Chlorination		
	Detention Period *min*	Type of Mixing	Mechanical Stirring	Rapid Mix	Tank Size *cu ft*	Detention Period *min*	Cleaning Arrangements	Point of Application	Type of Machine	Automatic Features
Ontario (contd.)										
Port Credit	upflow basin: 31-ft ID, 1,400-gpm (US) capacity						sludge removal at regular intervals	plant effluent	vacuum	proportional flow
Port Hope	34	spiral flow			8,320	125	cleaned every 6 months	raw & treated water	vacuum	none
Port Rowan					300	150	flushing through drain	settled water	vacuum (hypochlorinator)	automatic pump
Renfrew	40	mechanical	yes	yes		120–160	rotary sludge scrapers, central sludge pump		vacuum	proportional flow
Scarborough Twp.	38	mechanical	yes	yes		120	scraper mechanism	before & after filters	vacuum (ClO_2)	hydraulic & electrical
Toronto Twp.	30	spiral flow			18,000*	130	flushing through drain	raw & filtered water	vacuum (ClO_2)	
Trenton	40	spiral flow			8,400*	150	flushing through drain	raw & treated water	vacuum	converter off venturi tube on discharge to town
Vineland	30	mechanical	yes	yes	5,400	120	flushing through drain	raw & filtered water	vacuum	with high-lift pump
Wallaceburg	34	spiral flow			6,000*	120				

* Two units.

TABLE 3—*Mixing, Settling, and Chlorination Features of 1949–54 Plants (contd.)*

Province and Municipality	Mixing				Sedimentation			Chlorination		
	Detention Period *min*	Type of Mixing	Mechanical Stirring	Rapid Mix	Tank Size *cu ft*	Detention Period *min*	Cleaning Arrangements	Point of Application	Type of Machine	Automatic Features
Ontario (contd.)										
Windsor	23	paddles	yes	yes	190,000*	120	mud valves in floor, scraper, flushing	plant effluent	vacuum	postchlorination only
Quebec										
Asbestos										
Barville										
Crabtree Mills	30	mechanical	paddles	no	2,640*	240	drain to river	mixing chamber & filter lift	pressure	none
L'Abord-à-Plouffe	30	baffles			9,600	240	drain	plant effluent	pressure	none
L'Assomption	30	baffles			9,600	240	drain	after filters	pressure	none
Murdochville										
Pont Viau	30	baffles			12,800	240	drain	after filters	vacuum	none
Sillery										
Saskatchewan										
Portage la Prairie	55	upflow basin: 35-ft diam., 1,750-gpm (US) capacity					automatic sludge removal	after filters	vacuum	none
Regina	180	2 upflow basins: each 65-ft diam., 21-ft depth					automatic sludge removal	before & after filters	vacuum	none
Swift Current	60	upflow basin: 16,300 cu ft, 1,500-gpm (US) capacity						high-lift suction wells	vacuum	differential converter off venturi tube

* Two units.

TABLE 3—*Mixing, Settling, and Chlorination Features of 1949–54 Plants (contd.)*

Province and Municipality	Mixing				Sedimentation			Chlorination		
	Detention Period *min*	Type of Mixing	Mechanical Stirring	Rapid Mix	Tank Size *cu ft*	Detention Period *min*	Cleaning Arrangements	Point of Application	Type of Machine	Automatic Features
Armed Services Installations										
Alberta										
Camp Wainwright	30	mechanical	yes	yes	24,100*	160	central collection	clear well	vacuum	fully automatic
Manitoba										
Ft. Churchill		upflow basin		yes	4,400	90	sludge scraper	before & after filters	vacuum	
Rivers								before & after filters	vacuum	
Quebec										
St. Hubert	30	mechanical	paddles	no	6,600*	240	drain to storm sewer	mixing basin & filter effluent	pressure	none

* Two units.

TABLE 4

Details of Filters at 1949–54 Plants

Province and Municipality	No. of Filters Installed	Dimensions *ft*	Capacity Each Filter *gpm**	Design Rate *gpm/sq ft*	Depth of Sand *in.*	Effective Sand Size *mm*	Depth of Gravel *in.*	Underdrain System	Backwash Method	Wash Rate of Rise *ipm*	Filter Controls	Filter Surface Wash
Alberta												
Camrose	2		105	2	24	0.45	18	brass strainers	direct from mains	18	from clear well	
Castor	2	6×6	72	2		0.45–0.55	24	perforated pipe	pump	24	automatic	
Red Deer	4	23×16	736	2		0.45–0.55	24	Wagner blocks	pump	24	automatic	
Manitoba												
Brandon												
Minnedosa	2	5×5	50	2	27‡	0.62–0.70	21	homemade concrete blocks	fire pump idled		manual	Palmer sweeps
Morden	2†		75	2	24‡	0.62–0.70	24	brass pipe	fire pump idled		automatic	Palmer sweeps
Morris	2	5×6½	65	2	27	0.45–0.55	26	homemade concrete blocks	fire pump idled		manual	Palmer sweeps
Souris	2	5×5	50	2	27‡	0.62–0.70	21	homemade concrete blocks	pump		manual	Palmer sweeps
Ontario												
Alexandria	2	12×10	240	2	24	0.45–0.55	15	Miller blocks	pump	24	manual	Hankin fixed jets
Beamsville	2	7⅛×10½	150	2	24	0.45–0.55	15	Miller blocks	pump		automatic	Hankin fixed jets

* US gallons.
† Pressure filters.
‡ Anthracite coal.

TABLE 4—*Details of Filters at 1949–54 Plants (contd.)*

Province and Municipality	No. of Filters Installed	Dimensions *ft*	Capacity Each Filter *gpm**	Design Rate *gpm/sq ft*	Depth of Sand *in.*	Effective Sand Size *mm*	Depth of Gravel *in.*	Underdrain System	Backwash Method	Wash Rate of Rise *ipm*	Filter Controls	Filter Surface Wash
Ontario (contd.)												
Beaverton	2		120	2				perforated pipe	pump			
Brantford	2	24×22	1,056	2	‡			cast-iron pipe	pump	24	automatic	Palmer sweeps
Bronte	2		57	2		0.45–0.55		pipe	pump		automatic	
Burlington	2	24⅜×18½	750	2	27‡	0.6–0.8	12	Wheeler bottom	pump	18	automatic	
Delhi	2	8×12	160	2	‡	0.6–0.8		pipe	pump			
Hawkesbury	2	18×19½	700	2	27‡	0.6–0.8	14	Wagner blocks	pump		automatic	Palmer sweeps
Kingston	4	42×21	1,764	2	10‡, 20	0.62–0.70‡ 0.55	15	Miller blocks	pump	18	automatic	Palmer sweeps
New Toronto	12	16½×42	1,050	2	27‡	0.6–0.8	15	Miller blocks	pumps		automatic	Hankin fixed nozzles
Oshawa	2	42×21	1,765	2	27	0.4–0.5	18	cast-iron pipe		24	automatic	Palmer sweeps
Peterborough	3	17$\frac{5}{12}$×24	840	2	24	0.38–0.48	18	cast-iron pipe	pump	18	automatic	
Picton	2	13×13	338	2	‡	0.62–0.70	18	brass pipe				
Port Credit	3	12×14	336	2	30	0.4–0.5	0	Aloxite blocks	tank	24	automatic	
Port Hope	2	16×16	512	2	12‡, 18	0.62–0.70‡ 0.4–0.5	18	cast-iron pipe	pump	18	automatic	Palmer sweeps
Port Rowan	1		150	2					pump			
Renfrew	2	16×26	830	2	30‡	0.68–0.72	18	Miller blocks	pump	24	automatic	Palmer sweeps

* US gallons.
‡ Anthracite coal.

TABLE 4—*Details of Filters at 1949–54 Plants (contd.)*

Province and Municipality	No. of Filters Installed	Dimensions *ft*	Capacity Each Filter *gpm**	Design Rate *gpm/sq ft*	Depth of Sand *in.*	Effective Sand Size *mm*	Depth of Gravel *in.*	Underdrain System	Backwash Method	Wash Rate of Rise *ipm*	Filter Controls	Filter Surface Wash
Ontario (contd.)												
Scarborough Twp.	10	26×16	832	2	24	0.4–0.5	15	Miller blocks	pump	24	automatic	Hankin fixed nozzles
Toronto Twp.	2	16×32	1,024	2	12‡, 18	0.62–0.70‡ 0.4–0.5	18	Miller blocks	pump	24		Palmer sweeps
Trenton	2	15×15	450	2	12‡, 18	0.70–0.72‡ 0.4–0.5	18	cast-iron pipe	pump	16	automatic	Palmer sweeps
Vineland	2	10½×8	168	2	30	0.4–0.5	24		pump	24	automatic	
Wallaceburg	2	15×15	450	2		0.4–0.5		cast-iron grid			automatic	
Windsor	10	28×25	1,400	2	30	0.5	18	cast-iron grid	pumps	18	automatic	Palmer sweeps
Quebec												
Asbestos												
Barville												
Crabtree Mills	2	6×7	84	2	27	0.4–0.5	15	Miller blocks	pump	24	manual	Palmer sweeps
L'Abord-à-Plouffe	2	13×13	169	1	24	0.4–0.5	15	Wheeler bottom	pump	20	automatic	
L'Assomption	2	13×13	169	1	24	0.4–0.5	15	Miller blocks	pump	20	automatic	
Murdochville												
Pont Viau	3	17×17	289	1	24	0.4–0.5	15	Miller blocks	pump	18		
Sillery											automatic	

* US gallons.
‡ Anthracite coal.

TABLE 4—*Details of Filters at 1949–54 Plants (contd.)*

Province and Municipality	No. of Filters Installed	Dimensions *ft*	Capacity Each Filter *gpm**	Design Rate *gpm/sq ft*	Depth of Sand *in.*	Effective Sand Size *mm*	Depth of Gravel *in.*	Underdrain System	Backwash Method	Wash Rate of Rise *ipm*	Filter Controls	Filter Surface Wash
Saskatchewan												
Portage la Prairie	3	11½×16½	371	2	27	0.4–0.5	14	Wagner blocks	tank	23	automatic	Baylis fixed jets
Regina	4	17×37	1,258	2	26	0.57	18	Miller blocks	tank	24	automatic	fixed jets
Swift Current	3	12×15	360	2	27‡	0.6–0.7	15	Miller blocks	pump	23	automatic	fixed jets
Armed Services Installations												
Alberta												
Camp Wainwright	total 6 (3 installed)	14×13½	537	3	‡			Aloxite blocks	pumps	12	automatic	Palmer sweeps
Manitoba												
Ft. Churchill	4			3	28		20	brass strainers	pumps		manual	
Rivers	†											
Quebec												
St. Hubert	2	9×12	216	2	27	0.4–0.5	15	Miller blocks	pump	24	manual	Hankin fixed jets

* US gallons.
† Pressure filters.
‡ Anthracite coal.

TABLE 5

Recently Constructed Rapid Sand Filter Plants Used in Analysis

Province and Municipality	Source of Supply	Province and Municipality	Source of Supply
Alberta		*Ontario (contd.)*	
Castor		Renfrew	Bonnechere R.
Red Deer	Red Deer R.	Scarborough Twp.	L. Ontario
		Toronto Twp.	L. Ontario
Manitoba		Trenton	Trent R.
Brandon	Assiniboine R.	Vineland	L. Ontario
Minnedosa	Minnedosa R.	Wallaceburg	Chenal Ecarte R.
Morris	Red R.	Windsor	Detroit R.
Souris	Souris R.		
		Quebec	
Ontario		Asbestos	Nicolet R.
Alexandria	Garry R.	Barville	
Beamsville	L. Ontario	Crabtree Mills	Ouareau R.
Brantford	Grand R.	L'Abord-à-Plouffe	Riviere des Prairies
Burlington	L. Ontario	L'Assomption	L'Assomption R.
Hawkesbury	Ottawa R.	Murdochville	
Kingston	L. Ontario	Pont Viau	
New Toronto	L. Ontario	Sillery	St. Lawrence R.
Oshawa	L. Ontario		
Peterborough	Otonabee R.	*Saskatchewan*	
Picton	Bay of Quinte	Portage la Prairie	Assiniboine R.
Port Credit	L. Ontario	Regina	Buffalo Pond
Port Hope	L. Ontario	Swift Current	Swift Current Creek

TABLE 6

Cost Data for Certain Rapid Sand Filter Plants *

Province and Municipality	Cost			Province and Municipality	Cost		
	$	$/mgd	$/cap.		$	$/mgd	$/cap.
Alberta				*Ontario (contd.)*			
Castor	40,000	200,000	33.33	Scarborough Twp.	1,500,000	150,000	18.75
Red Deer	410,000	115,300	52.00	Toronto Twp.	357,500	143,000	17.80
				Trenton	400,000	400,000	26.40
Manitoba				Vineland	98,000	235,000	65.30
Minnedosa	56,000	280,000	24.35				
Morris	21,000	150,000	21.00	*Quebec*			
Souris	36,000	257,000	24.00	Crabtree Mills	100,000	500,000	83.30
				L'Abord-à-Plouffe	100,000	290,000	20.00
Ontario				L'Assomption	120,000	310,000	40.00
Alexandria	158,400	276,000	63.30	Pont Viau	300,000	450,000	26.10
Beamsville	140,000	350,000	70.00				
Hawkesbury	476,500	238,000	59.50	*Saskatchewan*			
Kingston	957,500	95,750	22.30	Regina	1,800,000	300,000	24.00
New Toronto	2,000,000	133,000	100.00				

* The additions at Scarborough Twp. and New Toronto, included in this list, are actually new plants, built around the existing installations.

NOT A STANDARD

FOR REFERENCE AND HISTORICAL RECORD ONLY

1908 CAST-IRON PIPE SPECIFICATIONS

Taken from the superseded AWWA "Standard Specifications for Cast-Iron Water Pipe and Special Castings"

The specifications for cast-iron pipe reproduced herein were adopted by the American Water Works Association May 12, 1908, as a part of its "Standard Specifications for Cast-Iron Water Pipe and Special Castings," and were withdrawn in 1939 in favor of the "American Standard Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids—ASA A21.2 (AWWA C102)." They are reprinted here for reference and for the convenience of engineers obliged to make repairs or replacements in pipelines originally manufactured in accordance with the old specifications. They are not to be construed as current or official AWWA specifications, however, and are not recommended for use.

Historical Edition; First Printing, July 1954

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Foreword

The pipe standards that are reprinted herein "for the record" are only a part of the original 1908 "Standard Specifications for Cast-Iron Water Pipe and Special Castings." When they were withdrawn in favor of the ASA cast-iron pipe standards adopted in 1939, the special-castings portion of the 1908 document remained valid and was kept in print as "Standard Specifications for Cast-Iron Special Castings—AWWA C100–08 (formerly 7C.1–1908)." For this reason, material dealing only with special castings has been deleted from this reprinting.

An ASA standard for short-body cast-iron fittings was adopted in 1952, but, as it did not include fittings larger than 12 in. in size, and as fittings already in the ground could only be replaced with other "long-body" castings, the C100–08 standard was not withdrawn. Instead, on Dec. 31, 1952, it was revised and renamed "Tentative Standard Specifications for Cast-Iron Pressure Fittings—AWWA C100–52T," under which title it may still be obtained as a valid AWWA specification.

A summary of the existing AWWA and ASA standards for cast-iron water pipe is given in the table on this page.

Replacing Old Pipe

When making replacements or extensions to pipelines manufactured in accordance with the 1908 specifications for cast-iron pipe that are reprinted herewith, it is necessary that the dimensions of the new pipe or fittings match those of the old. The limiting dimension is that shown in Table 1 of the document that follows as "Actual Outside Diameter."

Generally speaking, there is no problem if new bell-and-spigot pipe conforming to ASA A21.2, A21.6, or A21.8 is to be installed, as the proper

ASA Designation	AWWA Designation	Journal AWWA Issue	Subject of Specification
—	C100–52T	Mar. 1953	Cast Iron Pressure Fittings
A21.1–1939	C101–39	Dec. 1939	American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe
A21.2–1953	C102–53	Apr. 1953*	Cast Iron Pit Cast Pipe for Water or Other Liquids
A21.4–1953	C104–53	Apr. 1953*	Cement Mortar Lining for Cast Iron Pipe and Fittings
A21.6–1953	C106–53	Feb. 1953	Cast Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids
A21.8–1953	C108–53	Feb. 1953	Cast Iron Pipe Centrifugally Cast in Sandlined Molds, for Water of Other Liquids
A21.10–1952	C110–52	Nov. 1952	Short-Body Cast Iron Fittings, 3 Inch to 12 Inch, for 250-psi Water Pressure Plus Water Hammer
A21.11–1953	C111–53	Apr. 1953	A Mechanical Joint for Cast Iron Pressure Pipe and Fittings

* Summary of revisions; the changes were not extensive enough to warrant republication of the complete text of the specifications in the Journal.

outside diameter can be selected from those specifications to correspond with those in the 1908 specifications. New bell-and-spigot fittings likewise present no problem.

Mechanical-joint pipe specified by ASA A21.11, however, offers only one outside diameter for each size. For the 4- and 6-in. sizes, the A21.11 outside diameter corresponds only with Class A of the 1908 pipe. For the 8- to 24-in. sizes, the A21.11 diameters match Class A and Class B of 1908 pipe. For the 30- to 48-in. sizes, the A21.11 diameters correspond only with the 1908 Class B pipe. This limitation means, in effect, that connection of mechanical-joint pipe and fittings is always possible only with 1908 pipe of the size and class shown:

Size *in.*	Class
4, 6	A
8–24	A, B
30–48	B

For 1908 pipe of other sizes and classes than those given above, mechanical-joint fittings cannot be used. It is possible, however, to connect mechanical-joint pipe to such lines through an existing 1908 bell, because mechanical-joint spigots will fit any bell well enough to make a poured joint. If the 1908 line ends in a spigot, a standard sleeve or other fitting may be used to obtain the necessary bell.

Not a Standard—For Historical Record Only

1908 Cast-Iron Pipe Specifications

Sec. 1—Description of Pipes

The pipes shall be made with hub and spigot joints and shall accurately conform to the dimensions given in Tables 1 and 2. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft in length, exclusive of socket.

Pipes with thickness and weight intermediate between the classes in Table 2 shall be made of the same outside diameter as the next heavier class. Pipes with thickness and weight less than shown by Table 2 shall be made of the same outside diameter as the Class A pipe; and pipes with thickness and weight more than shown by Table 2 shall be made of the same outside diameter as the Class D pipe.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 in. from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

For pipes of each size from 4 in. to 24 in. inclusive, there shall be two standards of outside diameter, and for pipes from 30 in. to 60 in. inclusive, there shall be four standards of outside diameter, as shown by Table 1.

For pipes 4 in. to 12 in. inclusive, one class of special castings shall be furnished, made from Class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter as shown by Table 1, and shall be tapered back for a distance of 6 in.

For pipes from 14 in. to 24 in. inclusive, two classes of special castings shall be furnished; Class B special castings with Classes A and B pipes, and Class D special castings with Classes C and D pipes; the former shall have cast on them the letters "AB" and the latter "CD." For pipes 30 in. to 60 in. inclusive, four classes of special castings shall be furnished, one for each class of pipe, and shall have cast on them the letter of the class to which they belong.

Sec. 2—Allowable Variation in Diameter of Pipes and Sockets

Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint-room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipes shall not vary from the standard dimensions by more than 0.06 in. for pipes 16 in. or less in diameter; 0.08 in. for 18-in., 20-in., and 24-in. pipes; 0.10 in. for 30-in., 36-in., and 42-in. pipes; 0.12 in. for 48-in., and 0.15 in. for 54-in. and 60-in. pipes.

Sec. 3—Allowable Variation in Thickness

For pipes whose standard thickness is less than 1 in., the thickness of metal in the body of the pipe shall not be

more than 0.08 in. less than the standard thickness, and for pipes whose standard thickness is 1 in. or more, the variation shall not exceed 0.10 in., except that for spaces not exceeding 8 in. in length in any direction, variations from the standard thickness of 0.02 in. in excess of the allowance above given shall be permitted. . . .

Sec. 4—Defective Spigots May Be Cut

Defective spigot ends on pipes 12 in. or more in diameter may be cut off in a lathe and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 ft in length, exclusive of the socket.

In case the length of a pipe differs from 12 ft, the standard weight of the pipe given in Table 2 shall be modified in accordance therewith.

Sec. 5—Special Castings

* * *

Sec. 6—Marking

Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4-in. may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1908	1908	1908
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall not be less than 2 in. in length and $\frac{1}{8}$ in. in relief for pipes 8 in. in diameter and larger. For smaller sizes of pipes the letters may be 1 in. in length. The weight and the class letter shall be conspicously painted in white in the inside of each pipe and special casting after the coating has become hard.

Sec. 7—Allowable Percentage of Variation in Weight

No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 in. or less in diameter, and 4 per cent for pipes more than 16 in. in diameter, and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent.

* * *

Sec. 8—Quality of Iron

All pipes and special castings shall be made of cast iron of good quality, and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the three bars differ from those given below, a proper allowance therefor shall be made in the results of the tests.

Sec. 9—Tests of Material

Specimen bars of the metal used, each being 26 in. long by 2 in. wide and 1 in. thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars when placed flatwise upon supports 24 in. apart, and loaded in the center, shall support a load of 2,000 lb, and show a deflection of not less than 0.30 in. before breaking; or if preferred, tensile bars shall be made which will show a breaking point of not less than 20,000 psi.

Sec. 10—Casting of Pipe

The straight pipes shall be cast in dry sand molds in a vertical position. Pipes 16 in. or less in diameter shall be cast with the hub end up or down, as specified in the proposals. Pipes 18 in. or more in diameter shall be cast with the hub end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Sec. 11—Quality of Castings

The pipes and special castings shall be smooth, free from scales, lumps, blisters, sand holes, and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

Sec. 12—Cleaning and Inspection

All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

Sec. 13—Coating

Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300°F immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least 5 min.

The varnish shall be heated to a temperature of 300°F (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated the pipe shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

Sec. 14—Hydrostatic Test

When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipes shall be subjected are as follows:

	Pressure	
	20 in. and Larger *psi*	Less Than 20 in. *psi*
Class A Pipe	150	300
Class B Pipe	200	300
Class C Pipe	250	300
Class D Pipe	300	300

Sec. 15—Weighing

The pipes and special castings shall be weighed for payment under the supervision of the engineer after the application of the coal-tar pitch varnish. If desired by the engineer, the pipes and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 lb.

Sec. 16—Contractor to Furnish Men and Material

The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipe and special castings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

Sec. 17—Power of Engineer to Inspect

The engineer shall be at liberty at all times to inspect the material at the foundry, and the moldings, castings, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

Sec. 18—Inspector to Report

The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection.

Sec. 19—Castings to Be Delivered Sound and Perfect

All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipes or other castings which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the contractor shall not be held liable for pipes or special castings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation at or any time after they have received the coating.

Sec. 20—Definition of "Engineer"

Wherever the word "engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties intrusted to them.

TABLE 1—*Standard Dimensions of Pipe, Classes A, B, C, D**

x = ¾ in. on 3–6-in. sizes
v = $\frac{3}{16}$ in. on 3–6-in. sizes
x = 1 in. on 8–84-in. sizes
v = ¼ in. on 8–84-in. sizes

Nominal Diam. *in.*	Classes	Actual Outside Diam. *in.*	Diam. of Sockets		Depth of Sockets		*a* *in.*	*b* *in.*	*c* *in.*
			Pipe *in.*	Special Castings *in.*	Pipe *in.*	Special Castings *in.*			
4	A	4.80	5.60	5.70	3.50	4.00	1.5	1.30	0.65
4	B, C, D	5.00	5.80	5.70	3.50	4.00	1.5	1.30	0.65
6	A	6.90	7.70	7.80	3.50	4.00	1.5	1.40	0.70
6	B, C, D	7.10	7.90	7.80	3.50	4.00	1.5	1.40	0.70
8	A, B	9.05	9.85	10.00	4.00	4.00	1.5	1.50	0.75
8	C, D	9.30	10.10	10.00	4.00	4.00	1.5	1.50	0.75
10	A, B	11.10	11.90	12.10	4.00	4.00	1.5	1.50	0.75
10	C, D	11.40	12.20	12.10	4.00	4.00	1.5	1.60	0.80
12	A, B	13.20	14.00	14.20	4.00	4.00	1.5	1.60	0.80
12	C, D	13.50	14.30	14.20	4.00	4.00	1.5	1.70	0.85
14	A, B	15.30	16.10	16.10	4.00	4.00	1.5	1.70	0.85
14	C, D	15.65	16.45	16.45	4.00	4.00	1.5	1.80	0.90
16	A, B	17.40	18.40	18.40	4.00	4.00	1.75	1.80	0.90
16	C, D	17.80	18.80	18.80	4.00	4.00	1.75	1.90	1.00
18	A, B	19.50	20.50	20.50	4.00	4.00	1.75	1.90	0.95
18	C, D	19.92	20.92	20.92	4.00	4.00	1.75	2.10	1.05
20	A, B	21.60	22.60	22.60	4.00	4.00	1.75	2.00	1.00
20	C, D	22.06	23.06	23.06	4.00	4.00	1.75	2.30	1.15
24	A, B	25.80	26.80	26.80	4.00	4.00	2.00	2.10	1.05
24	C, D	26.32	27.32	27.32	4.00	4.00	2.00	2.50	1.25
30	A	31.74	32.74	32.74	4.50	4.50	2.00	2.30	1.15
30	B	32.00	33.00	33.00	4.50	4.50	2.00	2.30	1.15
30	C	32.40	33.40	33.40	4.50	4.50	2.00	2.60	1.32
30	D	32.74	33.74	33.74	4.50	4.50	2.00	3.00	1.50
36	A	37.96	38.96	38.96	4.50	4.50	2.00	2.50	1.25
36	B	38.30	39.30	39.30	4.50	4.50	2.00	2.80	1.40
36	C	38.70	39.70	39.70	4.50	4.50	2.00	3.10	1.60
36	D	39.16	40.16	40.16	4.50	4.50	2.00	3.40	1.80
42	A	44.20	45.20	45.20	5.00	5.00	2.00	2.80	1.40
42	B	44.50	45.50	45.50	5.00	5.00	2.00	3.00	1.50
42	C	45.10	46.10	46.10	5.00	5.00	2.00	3.40	1.75
42	D	45.58	46.58	46.58	5.00	5.00	2.00	3.80	1.95
48	A	50.50	51.50	51.50	5.00	5.00	2.00	3.00	1.50
48	B	50.80	51.80	51.80	5.00	5.00	2.00	3.30	1.65
48	C	51.40	52.40	52.40	5.00	5.00	2.00	3.80	1.95
48	D	51.98	52.98	52.98	5.00	5.00	2.00	4.20	2.20
54	A	56.66	57.66	57.66	5.50	5.50	2.25	3.20	1.60
54	B	57.10	58.10	58.10	5.50	5.50	2.25	3.60	1.80
54	C	57.80	58.80	58.80	5.50	5.50	2.25	4.00	2.15
54	D	58.40	59.40	59.40	5.50	5.50	2.25	4.40	2.45
60	A	62.80	63.80	63.80	5.50	5.50	2.25	3.40	1.70
60	B	63.40	64.40	64.40	5.50	5.50	2.25	3.70	1.90
60	C	64.20	65.20	65.20	5.50	5.50	2.25	4.20	2.25
60	D	64.82	65.82	65.82	5.50	5.50	2.25	4.70	2.60
72	A	75.34	76.34	76.34	5.50	5.50	2.25	3.80	1.87
72	B	76.00	77.00	77.00	5.50	5.50	2.25	4.20	2.20
72	C	76.88	77.88	77.88	5.50	5.50	2.25	4.60	2.64
84	A	87.54	88.54	88.54	5.50	5.50	2.50	4.10	2.10
84	B	88.54	89.54	89.54	5.50	5.50	2.50	4.50	2.60

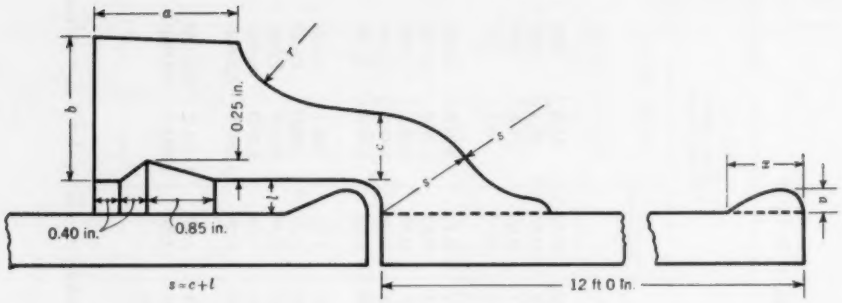
* Drawing accompanying Table 3 applies.

TABLE 2—*Standard Thickness and Weight of Cast-Iron Pipe, Classes A, B, C, D*

Nominal Inside Diam. *in.*	Class A 100-ft Head 43-psi Pressure			Class B 200-ft Head 86-psi Pressure			Class C 300-ft Head 130-psi Pressure			Class D 400-ft Head 173-psi Pressure			Nominal Inside Diam. *in.*
	Thickness *in.*	Weight, *lb*, per		Thickness *in.*	Weight, *lb*, per		Thickness *in.*	Weight, *lb*, per		Thickness *in.*	Weight, *lb*, per		
		Foot	Length		Foot	Length		Foot	Length		Foot	Length	
4	0.42	20.0	240	0.45	21.7	260	0.48	23.3	280	0.52	25.0	300	4
6	0.44	30.8	370	0.48	33.3	400	0.51	35.8	430	0.55	38.3	460	6
8	0.46	42.9	515	0.51	47.5	570	0.56	52.1	625	0.60	55.8	670	8
10	0.50	57.1	685	0.57	63.8	765	0.62	70.8	850	0.68	76.7	920	10
12	0.54	72.5	870	0.62	82.1	985	0.68	91.7	1,100	0.75	100.0	1,200	12
14	0.57	89.6	1,075	0.66	102.5	1,230	0.74	116.7	1,400	0.82	129.2	1,550	14
16	0.60	108.3	1,300	0.70	125.0	1,500	0.80	143.8	1,725	0.89	158.3	1,900	16
18	0.64	129.2	1,550	0.75	150.0	1,800	0.87	175.0	2,100	0.96	191.7	2,300	18
20	0.67	150.0	1,800	0.80	175.0	2,100	0.92	208.3	2,500	1.03	229.2	2,750	20
24	0.76	204.2	2,450	0.89	233.3	2,800	1.04	279.2	3,350	1.16	306.7	3,680	24
30	0.88	291.7	3,500	1.03	333.3	4,000	1.20	400.0	4,800	1.37	450.0	5,400	30
36	0.99	391.7	4,700	1.15	454.2	5,450	1.36	545.8	6,550	1.58	625.0	7,500	36
42	1.10	512.5	6,150	1.28	591.7	7,100	1.54	716.7	8,600	1.78	825.0	9,900	42
48	1.26	666.7	8,000	1.42	750.0	9,000	1.71	908.3	10,900	1.96	1,050.0	12,600	48
54	1.35	800.0	9,600	1.55	933.3	11,200	1.90	1,141.7	13,700	2.23	1,341.7	16,100	54
60	1.39	916.7	11,000	1.67	1,104.2	13,250	2.00	1,341.7	16,100	2.38	1,583.3	19,000	60
72	1.62	1,283.4	15,400	1.95	1,545.8	18,550	2.39	1,904.2	22,850	—	—	—	72
84	1.72	1,633.4	19,600	2.22	2,104.2	25,250	—	—	—	—	—	—	84

The above weights are per length to lay 12 ft, including standard sockets; proportionate allowance to be made for any variation.

TABLE 3—*Standard Dimensions of Pipe*
High-Pressure Service, Classes E, F, G, H



x = 1 in.
y = ¼ in.

Nominal Diam. *in.*	Classes	Actual Outside Diam. *in.*	Diam. of Sockets *in.*	Depth of Sockets *in.*	*a* *in.*	*b* *in.*	*c* *in.*	*r* *in.*	Nominal Diam. *in.*
6	E, F	7.22	8.02	4.00	1.50	1.75	0.75	1.10	6
6	G, H	7.38	8.18	4.00	1.50	1.85	0.85	1.10	6
8	E, F	9.42	10.22	4.00	1.50	1.85	0.85	1.10	8
8	G, H	9.60	10.40	4.00	1.50	1.95	0.95	1.10	8
10	E, F	11.60	12.40	4.50	1.75	1.95	0.95	1.10	10
10	G, H	11.84	12.64	4.50	1.75	2.05	1.05	1.10	10
12	E, F	13.78	14.58	4.50	1.75	2.05	1.05	1.10	12
12	G, H	14.08	14.88	4.50	1.75	2.20	1.20	1.10	12
14	E, F	15.98	16.78	4.50	2.00	2.15	1.15	1.10	14
14	G, H	16.32	17.12	4.50	2.00	2.35	1.35	1.10	14
16	E, F	18.16	18.96	4.50	2.00	2.30	1.25	1.15	16
16	G, H	18.54	19.34	4.50	2.00	2.55	1.45	1.15	16
18	E, F	20.34	21.14	4.50	2.25	2.45	1.40	1.15	18
18	G, H	20.78	21.58	4.50	2.25	2.75	1.65	1.15	18
20	E, F	22.54	23.34	4.50	2.25	2.55	1.50	1.15	20
20	G, H	23.02	23.82	4.50	2.25	2.85	1.75	1.20	20
24	E, F	26.90	27.90	5.00	2.25	2.85	1.70	1.20	24
30	E	33.10	34.10	5.00	2.25	3.25	1.80	1.50	30
30	F	33.46	34.46	5.00	2.25	3.50	2.00	1.55	30
36	E	39.60	40.60	5.00	2.25	3.70	2.05	1.70	36
36	F	40.04	41.04	5.00	2.25	4.00	2.30	1.80	36

TABLE 4—*Standard Thickness and Weight of Cast-Iron Pipe*
For Fire Lines and Other High-Pressure Service—Classes E, F, G, H

Nominal Inside Diam. *in.*	Class E 500-ft Head 217-psi Pressure			Class F 600-ft Head 260-psi Pressure			Class G 700-ft Head 304-psi Pressure			Class H 800-ft Head 347-psi Pressure			Nominal Inside Diam. *in.*
	Thickness *in.*	Weight, *lb.* per		Thickness *in.*	Weight, *lb.* per		Thickness *in.*	Weight, *lb.* per		Thickness *in.*	Weight, *lb.* per		
		Foot	Length		Foot	Length		Foot	Length		Foot	Length	
6	0.58	41.7	500	0.61	43.3	520	0.65	47.1	565	0.69	49.6	595	6
8	0.66	61.7	740	0.71	65.7	790	0.75	70.8	850	0.80	75.0	900	8
10	0.74	86.3	1,035	0.80	92.1	1,105	0.86	100.9	1,210	0.92	106.7	1,280	10
12	0.82	113.8	1,365	0.89	122.1	1,465	0.97	135.4	1,625	1.04	143.8	1,725	12
14	0.90	145.0	1,740	0.99	157.5	1,890	1.07	174.2	2,090	1.16	186.7	2,240	14
16	0.98	179.6	2,155	1.08	195.4	2,345	1.18	219.2	2,620	1.27	232.5	2,790	16
18	1.07	220.4	2,645	1.17	238.4	2,860	1.28	267.1	3,205	1.39	286.7	3,440	18
20	1.15	263.0	3,155	1.27	286.3	3,435	1.39	320.8	3,850	1.51	344.6	4,135	20
24	1.31	359.6	4,315	1.45	392.9	4,715	—	—	—	—	—	—	24
30	1.55	521.7	6,260	1.73	585.4	7,025	—	—	—	—	—	—	30
36	1.80	725.0	8,700	2.02	820.0	9,840	—	—	—	—	—	—	36

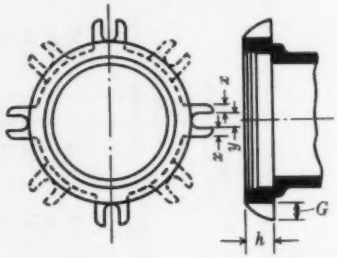
The above weights are per length to lay 12 ft, including standard sockets; proportionate allowance to be made for any variation.

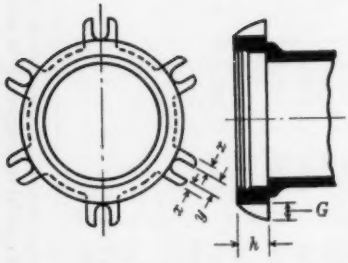
For high-pressure pipe from 6 to 24 in. inclusive, one class of special castings shall be furnished for Classes E and F pipe, and one class of special castings for Classes G and H pipe. For 30- and 36-in. pipe, one class of special castings shall be furnished for each class of pipe.

TABLE 5—*Standard Lugs*

Number and Weight of Lugs on Outlets of Different Sizes

4 Lugs, 12-14 in.
8 Lugs, 42-60 in.





6 Lugs, 16-36 in.

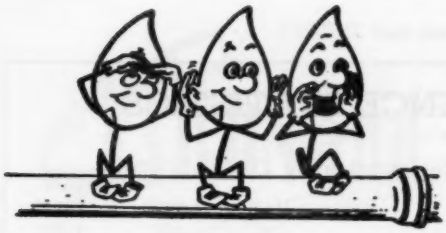
Nominal Diam. Outlet *in.*	No. of Pairs of Lugs	Approx. Weight, Lugs on One Bell *lb*	Nominal Diam. Outlet *in.*	No. of Pairs of Lugs	Approx. Weight, Lugs on One Bell *lb*
12	4	32	30	6	80
14	4	32	36	6	80
16	6	56	42	8	111
18	6	56	48	8	114
20	6	56	54	8	134
24	6	56	60	8	137

Two pairs of lugs are placed on the vertical axis of each bell, the others at equal distances around circumference. h is equal depth of bell on all sizes.

G equals 2.50 in., x equals 1.25 in., y equals 1.63 in. for 12 to 24 in. inclusive.

G equals 3.00 in., x equals 1.50 in., y equals 2.00 in. for 30 to 60 in. inclusive.

NOTE: As a table of lugs also appears, in different form, in specifications AWWA C100 for cast-iron pressure fittings, it is suggested that reference be made to that document.



Percolation and Runoff

AWWA's four-minute mile, dashed off last May 23–28 in Seattle, totaled 4,126 feet—those, that is, belonging to the 2,063 members and guests who then and there established a new conference registration record, topping Philadelphia's 1950 mark by a fat 56. And the registration total was only a finishing touch to a convention that was record in every respect, from the opening of exhibits and entertainment on Sunday afternoon through the tours that kept the program going on into Friday evening. Everything—at any rate, everything but the weather—was much more than just successful. *Tre*mendous was the word for this 74th annual conference of AWWA.

*Tree*mendous, too, for, from the outer lobby right through, the Seattle Water Dept. had decorated the Civic Auditorium with trees—live evergreens from its watershed around the stage and at the entry, free seedlings from its nursery as permanent souvenirs of the meeting, and a 9-ft cross-section of a watershed fir that antedated the discovery of America. Even the technical program was treed, a Weyerhaeuser Timber Co. film and a discussion of watershed logging practices leading off the series of ten regular sessions in which 67 speakers took up all the major concerns of water works practice. On the exhibit floor, meanwhile, it was the fruit of Washington's trees that was the center of attraction—apple juice, that is, or perhaps the anything but wooden model who served it—around which 90 of AWWA's Associate Members displayed the finest equipment and material available to the field in 150 booths covering more than 14,000 square feet of exhibit space.

And when the Auditorium day was done—the technical sessions, the committee meetings, the inspection trips, the booth shopping—the evening fun began. Sunday started the program off with a real bang when 756 buffeters took over the Washington Athletic Club dining room and were joined by still more for the meeting and greeting which followed. On Monday another large turnout cheered Honorary Members Ben Morrow, Sam Newkirk, and Leonard Thompson (the latter two in absentia, Sam recovering from a heart attack and Leonard at the bedside of his very sick wife), Diven Medalist Bill Orchard, Goodell Prizewinner Mike Taras, and 27 Fuller Awardees as they received their awards, before this year's officers took over to host the reception and dance which followed. Tuesday night turned back the clock to the 1890's for a Klondike Kickup which specialized in informality, gam-

(*Continued on page 34 P&R*)

(Continued from page 33 P&R)

1954 CONFERENCE STATISTICS

(Story on p. 33 P&R)

Grand Rapids Registration by Days

Day	Men	Ladies	Total
Sunday, May 23	929	349	1,278
Monday, May 24	435	152	587
Tuesday, May 25	120	26	146
Wednesday, May 26	32	—	32
Thursday, May 27	20	—	20
TOTALS	**1,536**	**527**	**2,063**

Geographic Distribution of Registrants

UNITED STATES & TERRITORIES

Alabama	20	Maine	11	Texas	46
Alaska	6	Maryland	13	Utah	15
Arizona	8	Massachusetts	13	Virginia	6
Arkansas	6	Michigan	41	Washington	426
California	267	Minnesota	21	West Virginia	4
Canal Zone	1	Mississippi	4	Wisconsin	45
Colorado	29	Missouri	44	Wyoming	3
Connecticut	8	Montana	12		
Dist. Columbia	5	Nebraska	16	**CANADA**	
Florida	15	New Jersey	85		
Georgia	19	New Mexico	1	Alberta	1
Hawaii	4	New York	135	British Columbia	42
Idaho	24	North Carolina	18	Manitoba	1
Illinois	101	North Dakota	8	Ontario	29
Indiana	42	Ohio	29	Quebec	1
Iowa	28	Oklahoma	13		
Kansas	27	Oregon	167	**FOREIGN**	
Kentucky	21	Pennsylvania	101		
Louisiana	19	Rhode Island	14	Australia	1
		South Carolina	10		
		South Dakota	22	**TOTAL**	**2,063**
		Tennessee	15		

Comparative Registration Totals—1946–1954

Year	Place	Men	Ladies	Total
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967
1948	Atlantic City	1,348	356	1,704
1947	San Francisco	1,115	431	1,546
1946	St. Louis	1,303	214	1,517

Win, Place & Show in Section Awards

Henshaw Cup	Hill Cup	Old Oaken Bucket
Pacific Northwest..67.5%	**Southwest 50.51**	**California 1,056**
California 62.3%	Pacific Northwest..18.80	Southwest 915
Rocky Mountain ..60.3%	Southeastern 17.83	New York 738

(Continued on page 36 P&R)

YARDS and YARDS of Aqua Nuchar

A cubic inch of AQUA NUCHAR —activated carbon—has a surface area of 20,000 square yards —that is, yards and yards of adsorptive quality! In addition, AQUA NUCHAR is specifically manufactured in a degree of lightness that enables it to remain in suspension, thereby prolonging its purification work. INDUSTRIAL'S Technicians, as part of their regular services, and *without obligating you,* will run an odor survey of your plant to determine when and how AQUA NUCHAR may be most efficiently applied in your present system.

AQUA NUCHAR—activated carbon—is the *established* product for achieving water which will be agreeable to the senses of taste and smell. INDUSTRIAL'S Technical Service Department will work with you to determine how—with AQUA NUCHAR—you may rapidly and efficiently obtain the most palatable water.

Contact INDUSTRIAL, now!

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division west virginia pulp and paper company

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35 E. Wacker Dr.
Chicago 1, Ill.

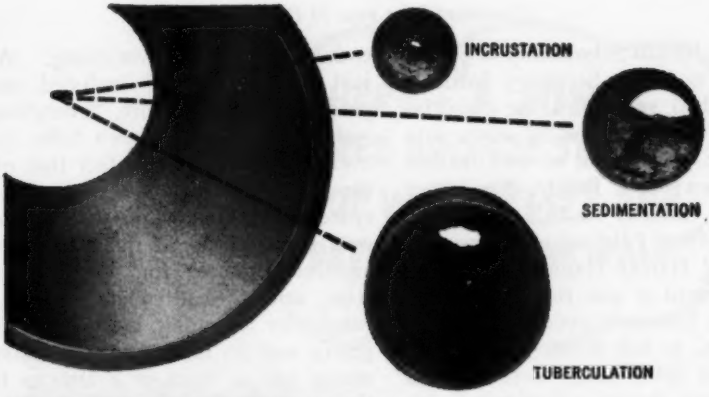
Lincoln-Liberty Bldg.
Broad & Chestnut
Phila. 7, Pa.

2775 S. Moreland
Blvd.
Cleveland 20, Ohio

(Continued from page 34 P&R)

bling for fake stakes and real prizes, square square dancing, and highly styled costumes that won for can-can cutie Helen Parks and Eskimo Reg Hayes highest honors for authenticity. Actually Mrs. Parks won from barely less can-canny Mrs. R. C. Schaefer merely by a hat, which no one but the judges even bothered to look at; and Reg, the robust refugee from a Back Bay igloo, just managed to rub out dudey-dandy Bill Orchard by a nose. Wednesday saw 450 strong defy the chill of an unseasonable evening to take a Starlight Cruise from Lake Washington through the canal out into Puget Sound to see the sights and lights of Seattle. And Thursday brought a capacity crowd of 800 to the Inaugural Banquet and Ball to pamper their palates with Puget Sound salmon, to cheer the Southwest, Pacific-Northwest, and California Sections for winning the Hill, Henshaw, and Old Oaken Bucket awards, to congratulate Morrison Cunningham on a banner year of presidency, and to greet new prexy Dale Maffitt. Surprises of the evening were the presentation of a special citation and scroll from the Governor of Iowa to incoming President Dale Maffitt by Mayor Joe Lawlor of Ames, Iowa (see cut); the announcement by Bill Orchard of the Water & Sewage Works Manufacturers Association's establishment of a

(Continued on page 38 P&R)



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National knows how to clean the difficult jobs, including hard incrustations, unusual obstructions and pipes of unusually large or small diameter.

National knows how to clean long runs with a minimum number of pipe entries.

National knows how to avoid trouble, such as can occur from improper provision for drainage of flush water from large mains or from the use of excessive pressures.

National knows how to clean so thoroughly that restoration of 95% of the original pipe capacity is guaranteed.

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(Continued from page 36 P&R)

Harry E. Jordan Scholarship of $1,500 per year to honor Secretary Jordan's distinguished service to the Association and to encourage the entry into the water works field of well trained young men; and, finally, the rather uncertain hilarity with which the "yokes" of that "distinguished Swedish engineer," Halvar Hammarskot, were received until it was realized that he had "yust ban come over" from Everett, Wash., to tell them.

Not just the evenings were reserved for pleasure, though. Beginning with a Monday brunch, the ladies' program kept 527 of the fair sex busy with sightseeing and luncheoning every day of the week. Monday was a busy day for golfers, with Mel Hatcher and George McDonough sharing the operators' honors as low netter and low grosser, and T. W. Fauntleroy and Marv Schroder netting and grossing first prizes among the manufacturers. Lady divotees, meanwhile, were led by Mrs. Ted McKey, low net, and Mrs. Frank Mueller, low gross. On Wednesday, early birds were the Fuller Awardees, 80 of whom managed to make the 7:30 breakfast at which Fred Merryfield, this year's chairman, presided over distribution of the "worms" and the balance of the morning's relaxatives. And all during the week, luncheon meetings of the Pacific-Northwest, California, and Wisconsin Sections, of the manufacturers association, and of various other groups kept the middays busy. Then on Friday almost everyone took off for Bremerton, Victoria, Seattle's Cedar River Watershed, or Alaska, on one of the tours worked out by the local committees.

What was so wonderful about Seattle was the fact that everybody was enthusiastic about everything. And just as "everybody" included more people than ever before, "everything" included a program much fuller than ever before—so full in fact that only the highest of high spots have found space here. Meanwhile, with courtesy cars standing by at the Auditorium, sightseeing buses for the inspection trips, and special courtesy tour arranged for the ladies, the local Section group saw to it that no one missed seeing just as much of Seattle as free time permitted. That wasn't all the local Section group saw to. As a matter of fact, under the leadership of Chairman Roy Morse of the Convention Management Committee, it saw to more things more eagerly and more efficiently than any other group ever. Working right with Roy as first assistants on the committee were W. A. Kunigk and Fred Merryfield, together with Tom Quigley and Sig Sigworth of the manufacturers, and Dick Wolff and Beth Morse superintending the ladies' events. Then, heading the local committees were Jerry Allen, Emil Jensen, Max Campbell, Bill Tinniswood, Don Bixby, Charlie Rossio, Fred Shanaman, Brian Shera, Clare Parks, Trumbull Smith, Arthur Musgrave, Cliff Casad, and the Bob Jacksons. Altogether, well over 200 of the Pacific-Northwesters served on these committees and many more families and friends volunteered their assistance—and it was their enthusiasm that carried over into the program itself to make everyone certain that this was not only the biggest but the best meeting ever.

Small wonder that Chicagoans have already felt it necessary to get under way on plans for even bester next year —June 12–17.

(Continued on page 40 P&R)

IT SAYS HERE - "A JONES ENGINEERED BRONZE SERVICE STOP WILL UPLIFT THE DEPARTMENT MORALE."
WATER DEPT.
EST. 1892
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JAMES JONES COMPANY
321 N. TEMPLE CITY BLVD. • EL MONTE, CALIF.
Bronze Goods for: WATER SERVICE
Gas Service • Oil Service • Fire Protection

(*Continued from page 38 P&R*)

An artist, and, thus, one whose work must be judged by its results, is the way in which Col. A. H. Bell, president of the British Society of Dowsers, characterized the diviner in his part of the argument on water divining, published in last month's issue of the *Journal of the Institution of Water Engineers.* "Many diviners have in the past acquired a reputation which can only be the outcome of successful accomplishment," he pointed out, but, then, lest we be too harsh in applying the suggested standard, he warned that "an unfavorable mental atmosphere is sufficient in itself to inhibit the diviner's reactions" and, as the practice of divining is "mainly a radio-physical process of great delicacy, it demands that there should be no objects of a disturbing nature, such as high-tension cables, iron railings, or large masses of metal in close proximity to the operator." In short, a diviner is one whose work must be judged by his successful results—and, even there, sympathetically.

Not to be too unartistic in our judgment of the diviner's art or of this exposition of it, we were yet rather taken aback at Col. Bell's hacking away at his own grass roots, with:

> The unlettered yokel, though still to be found in the countryside, has largely been replaced by the man of education. It is now known that the gift can be developed by practice in nearly every human being, and that a few possess it naturally in a marked degree. Many years ago, it was observed by Sir William Barrett that the movements of the twig were due to muscular action, which was entirely involuntary, on the part of the diviner himself. The "magic twig" has now been largely

(*Continued on page 42 P&R*)

Depend on Cyanamid's

ALUM

for 6 good reasons

1. It feeds uniformly, without trouble, in solid or liquid form.
2. It has a wide pH range for effective coagulation.
3. It forms floc rapidly.
4. It gives maximum adsorption of suspended and colloidal impurities.
5. It causes minimum corrosion of feeding equipment.
6. It is available in granular form or in the new easy-to-use liquid form.

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3.

1. Large illustration shows Singl-use Fiberform ready to be filled.
2. Filling plate and collar simplify pouring concrete into form.
3. Completed meter box barrel.
4. Meter box with cover in place.

4.

FOR ECONOMICAL SETTINGS

1.

Make Your Own

CONCRETE METER BOX BARRELS *with*

FORD *Singl-use Fiberforms*

Water utilities that find vitrified or concrete tile expensive or difficult to obtain, may now make their own barrels for outside meter settings with Ford Singl-use Fiberforms which are inexpensive and easy to use. Forms made for 15", 18" and 20" ID barrels and in lengths of 15", 18" and 24". Use two for deep settings. Send for full information.

FOR BETTER WATER SERVICES

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THE FORD METER BOX COMPANY, INC. Wabash, Indiana

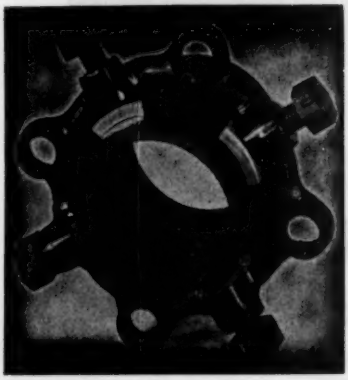
(*Continued from page 40 P&R*)

discarded in favour of more convenient and more sensitive indicators of the muscular reflexes. . . .

Apart from a few natural water diviners of the old-fashioned type, the number of really reliable operators on modern lines is inconsiderable. This fact is not generally recognized, and water diviners are often employed without any prior investigation of their qualifications. [And what was that he said about reputation?] When, as a result, failures occur, employers have only themselves to blame.

All this, of course, lightens our load considerably. Now, we are in the happy position of being on the side of both engineering and rhabdomancy when we discount the reported successes of such country-cousin twig-twitchers as Henry Gross of Kennebunkport, Me., whose prowess Episcopal Bishop William Scarlett acclaimed last December; or Roy McMillan of Pleasant Plains, Ill., who attests his own success in helping neighbors beat last March's drought; or Charles S. Birely of Camp Springs, Md., whose Pennsylvania Dutch technique is sworn to even by a Prince Georges County Commissioner; or Harvey Mathews of Pittstown and Oscar Wolfe of Flemington, N.J., who jointly rescued the city of Lambertville, N.J., from last month's thirst. Not realizing that it is "electromagnetic radiation, ionization, changes of potential, or changes in magnetic fields" that they are playing with—and that "cosmic radiation is in most cases the original energizing force"—they are ill prepared to interpret their own spasms and paroxysms and, thus, by a master dowser's own standards, must be considered untrained and unreliable. Who are we to disagree?

(*Continued on page 44 P&R*)



ANCHORED CLAMP for MECHANICAL JOINTS

Also CI-60 charcoal cast iron bolts for mechanical joints; bell-joint Leak Clamps and Gasket Sealer Compound.

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LAST THE LIFE OF THE PLANT

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THESE ADVANTAGES:

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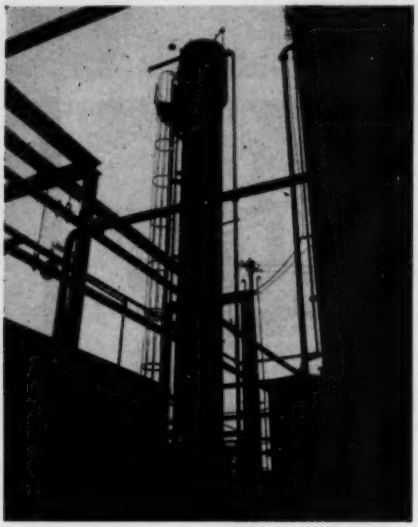
(Continued from page 42 P&R)



Industrial waste treatment plants have been announced, appropriately enough, by two firms which are also water works suppliers. Armco Steel Corp. of Middletown, Ohio, is planning a clarifying system which will permit reuse of 10 mgd of water at its East Works plant, with corresponding benefit to its hard-pressed sources of supply—the Miami River and the Miami Valley aquifers. In addition to reducing the intake of river water, the quality of water returned will be better than that taken.

Already in operation is the Koppers Co. treatment plant at its Follansbee, W.Va., tar products plant, which is reducing the phenol content of its waste waters from 3,000 ppm to 50 ppm before dilution with Ohio River water. The extraction plant uses a Koch column (above) to separate the phenol, and has a capacity of 200,000 gpd.

Leo Louis Jr., Cedar Rapids, Iowa, Water Works Dept. superintendent, has become manager of the Gary-Hobart Water Corp., Gary, Ind.

On the House were the drinks set up for a Soil Conservation Service crew working at Overton, Nev., last year, but it took the General Accounting Office many months of deliberation to approve the claim for the treat. As a matter of fact, not until the local authorities themselves admitted that the water at Overton was not fit to drink and was used by the natives only for irrigation purposes would the scandal-wary GAO, with a strong admonition concerning "regular administrative channels," okay payment. So Uncle Sam finally anted up his buck for the 50 gallons of imported Las Vegas stuff which the crew had tossed off. The "stuff," of course, was water —at *what* a price!

Too late for his elevation to be celebrated in these pages while he was in office, it was learned that T. Carr Forrest, partner in the Dallas, Tex., consulting firm of Forrest & Cotton, has been serving as president of the National Society of Professional Engineers, his one-year term ending on June 30, 1954.

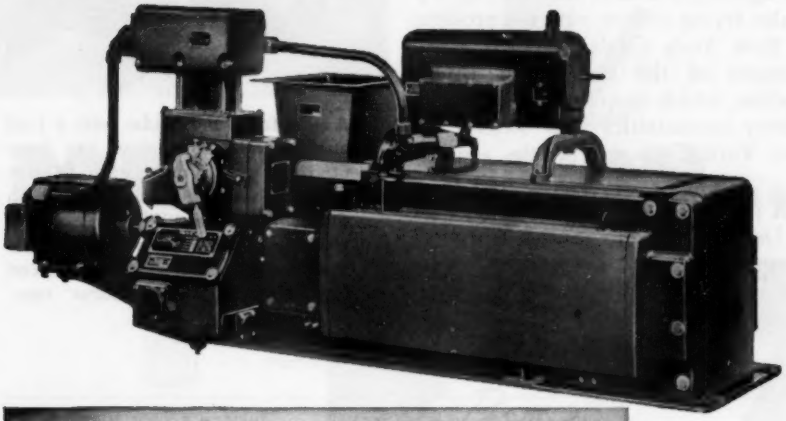
Among the slate of officers elected for the 1954–55 year is another AWWA member—Louis F. Frazza, manager of direct sales for the Transite Pipe Dept. of Johns-Manville Sales Corp., New York. He serves as NSPE vice-president for the Northeastern Area.

Reginald C. Price, who has been director of the Water & Power Div. of the Dept. of Interior, has joined the Economic Commission for Asia and the Far East (ECAFE) of the United Nations, with headquarters at Bangkok, Thailand. He will work on the planning and economic analysis of water and multipurpose river basin development projects for the region.

(Continued on page 46 P&R)

The best "WEIGH"...
is the MERCHEN way!

W&T Merchen Feeders give precision feeding of any waterworks chemical...*by weight.*



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—Durable construction, sealed bearings and dust shields.

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—Remote feed rate adjustment if desired.

—Adaptable to fully automatic proportional control.

Hundreds of installations feeding waterworks chemicals, industrial chemicals and feed and flour ingredients have proved the accuracy and dependability of these belt-type gravimetric feeders.

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USE W&T FEEDERS FOR
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WALLACE & TIERNAN
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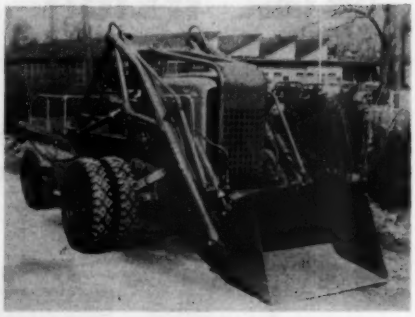
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY — REPRESENTED IN PRINCIPAL CITIES

(Continued from page 44 P&R)

S. P. Carman, consultant of Binghamton, N.Y., was appointed engineer of the new Westchester County, N.Y., water agency, and will study future sources of water supply for the county. James C. Harding, county public works commissioner and chairman of the agency, indicated that the agency is also trying to cope with the problem of New York City's proposed abandonment of the century-old Bronx pipeline, which supplies several Westchester communities with water from New York City's watershed.

A new sales office has been opened in Detroit by Reilly Tar & Chemical Corp., with A. F. McDonald in charge. The office is located at 3049 E. Grand Blvd., Detroit 2, Mich.



A new front-end loader with a ¾-yd bucket and snow plow has been produced by Worthington Mower Co., Stroudsburg, Pa., for use with the firm's Model "F" tractor. The tractor uses front-wheel drive for improved traction under front-end loading, and also features rear-wheel steering.

(Continued on page 48 P&R)

WHY USE JOHNSON WELL SCREENS?

1. **Less drawdown.**
2. **Greater specific capacity.**
3. **Lowest pumping cost per million gallons of water.**

True economy is measured not by first cost alone, but in lowest yearly cost. The JOHNSON WELL SCREEN combines an unmatched record of experience and dependability with greatest strength and durability. It is the finest and most truly economical well screen in the world.

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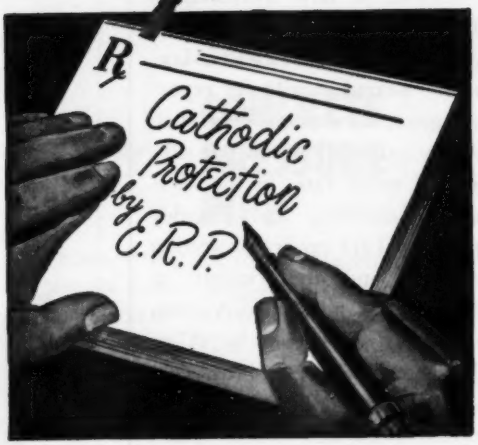
Rx FOR CORROSION...



You don't need a specialist to *recognize* Corrosion. But you do need one to treat it successfully. The skill required to achieve complete corrosion control comes only from the knowledge and experience gained through years of practical application.

Recognition of that fact is one reason more and more people are turning to E.R.P. for assistance on corrosion problems—one reason that thousands of buried or submerged steel structures of all types have been successfully protected against corrosion by E.R.P. engineers. Corrosion specialists *for over 17 years*, these men are highly trained and well equipped to help you with *your* corrosion problem. Write for full information today.

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REPRESENTED IN PRINCIPAL CITIES IN THE UNITED STATES

-E27

Announcing!

AWWA WATER RATES MANUAL

The report of the AWWA Committee on Water Rates published in the March 1954 JOURNAL is now available in reprint form as part of the AWWA "Water Rates Manual." Bound in with the report are generous excerpts from such classic publications on the subject of water rates as the Metcalf, Kuichling, and Hawley paper of 1911 on fire protection charges and the reports of NEWWA and AWWA committees chairmanned by Allen Hazen, as well as a table of cost indexes, an outline for allocation of plant and expenses, and other valuable supplementary material.

64 pages **$1.00**

American Water Works Association

521 Fifth Ave., New York 17, N. Y.

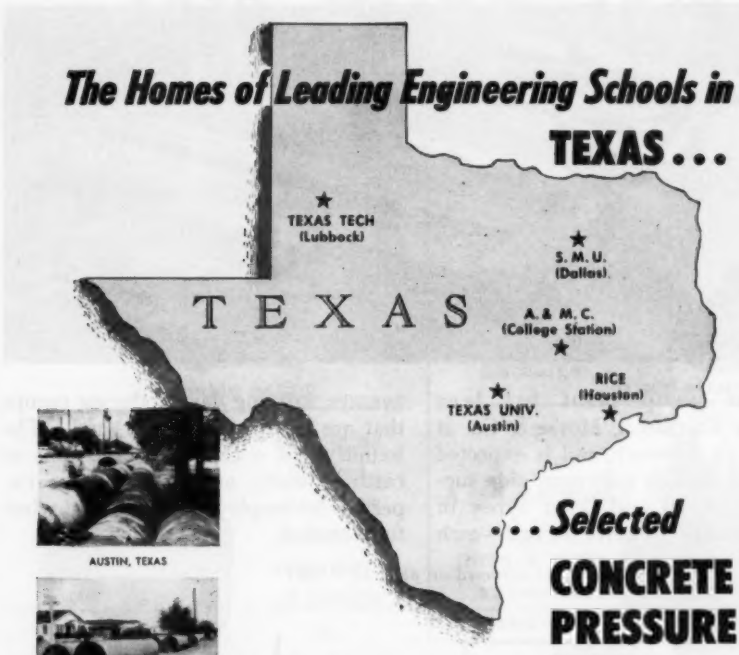
(*Continued from page 46 P&R*)

A redesigned and improved version of its loss-in-weight indicator-recorder for volumetric chemical feeding has been announced by Omega Machine Co., Providence, R.I., and received its first public showing at the Seattle conference. The equipment provides a continuous indication of

hopper contents and a permanent record of feeder operation. When combined with the Model 50 Disc Feeder, as shown (above), it offers volumetric feeding with significant features of gravimetric machines, but at much less cost. Recommended applications include fluoridation, coagulation, and pH control.

(*Continued on page 50 P&R*)

The Homes of Leading Engineering Schools in TEXAS . . .



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LUBBOCK, TEXAS

COLLEGE STATION, TEXAS

. . . Selected CONCRETE PRESSURE PIPE

The five cities shown on the above map where the leading Engineering Schools of TEXAS are located have large CONCRETE PRESSURE PIPE installations in their water systems. In other words, the Engineers of today selected for the Engineers of tomorrow CONCRETE PRESSURE PIPE through which they receive pure clear sparkling drinking water. Such popularity of Concrete Pressure Pipe in Texas must be deserved.

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Concrete PRESSURE Pipe

WATER FOR GENERATIONS TO COME

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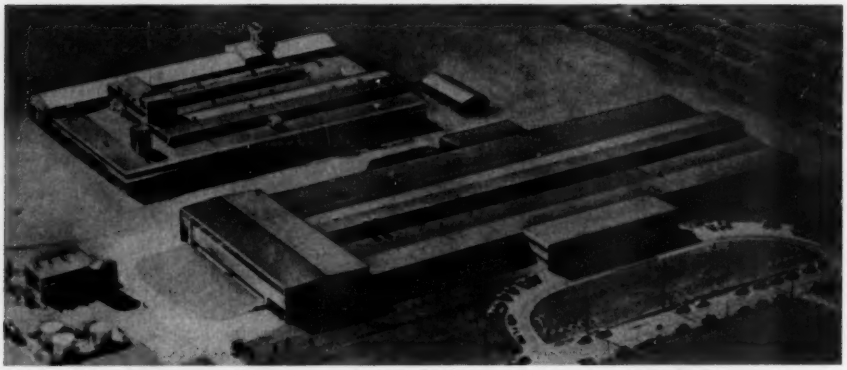
Chicago 1, Illinois

(Continued from page 48 P&R)



A new pump plant has been opened by Fairbanks, Morse & Co. at Kansas City (above), and is expected to produce enough split-case, side suction, angle-flow, and other types of pumps annually to move 35 bgd—each average working day producing pumps that are rated at over 100 mgd. The foundry has a capacity of 70 tons of castings daily, and the plant is expected to employ 900 persons when fully staffed.

(Continued on page 52 P&R)

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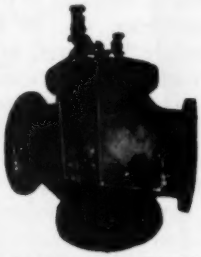

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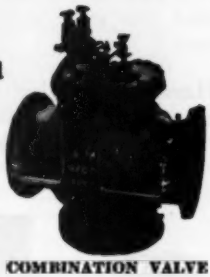
REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

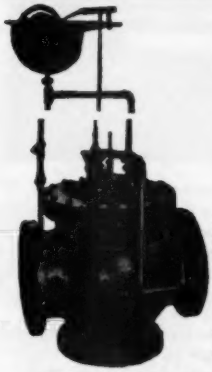
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.



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(*Continued from page 50 P&R*)

The upbubblement theory of hydrologic cycling miscredited to A. Leonard Davidson in the April issue (p. 34 P&R) and dismiscredited by James E. Hackett in this month's Correspondence (p. 56 P&R) was unwittingly boostered at the 120th session of the American Assn. for the Advancement of Science by USGS staff geologist William R. Rubey, whose hypothesis it is that "water has been rising out of the deep center of the earth continuously ever since the creation of the earth," three billion or so years ago. That's a little beyond our depth, but as far as we're concerned, the more rise and shine the better!

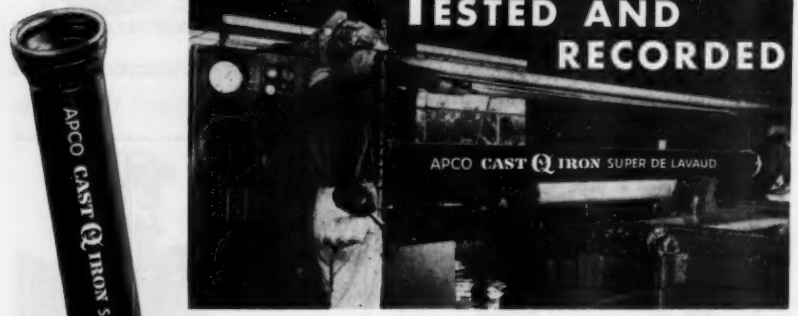
Harry Faber has been advanced from associate editor to managing editor of *Water & Sewage Works.*

W. Leslie Harris, formerly water plant supervisor, has been appointed superintendent of the Dept. of Water & Light, Grand Rapids, Mich.

George E. Symons has been appointed a research associate in the Research Div. of the College of Engineering, New York Univ., and will coordinate the division's air and water pollution studies on a part-time basis. He continues to maintain his office in Larchmont, N.Y.

Anhydrous ferric chloride capacity has just been doubled by Pennsylvania Salt Mfg. Co., in order to meet the demand for water and sewage treatment and other industrial processes. The increase is the result of a new production plant at Pennsalt's Wyandotte, Mich., works.

(*Continued on page 54 P&R*)



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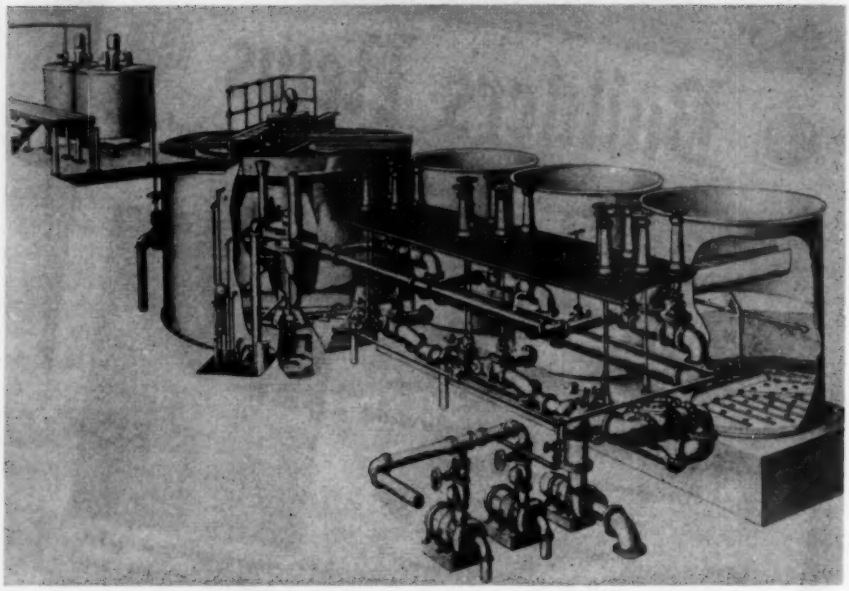
METERS FEEDERS CONTROLS

(*Continued from page 52 P&R*)



A new package water treatment plant offered by Graver Water Conditioning Co. combines (left to right) chemical feeders, Reactivator for clarification or softening by solids-contact process, and filters. Plants are available in a capacity range from 0.1 to 2.0 mgd.

Goddessless is what we are, now that Bethesda, "goddess of water," has been ousted from Olympus on the grounds of illegal entry. Putting the finger on our now nullified nymph were representatives of the Monument Div. of the New York City Parks Dept., the Library of Congress, and the Hebrew Union College–Jewish Institute of Religion, all of whom agreed that the five-foot female whose statue had been erected at a city fountain some 150 years ago was not nor ever had been a goddess at all. "Bethesda," the inscription said, "goddess of water, with faith, hope and charity, bringing water to Tompkins Square Park." But Bethesda, it appears, is no more than the name of the Jerusalem pool of healing water, after which so many of our hospitals have been named. Rabbi Kiev's explanation that "Bethesda" came from the Aramaic "Beth Hesda," meaning house of grace, of loving kindness, of fishes, or of olives, and the fact that the name on the statue base was "scarcely legible," led us to the conviction that a goddess was involved after all—Hestia, that is, goddess of the hearth—the inscription undoubtedly reading: "Bath Hestia," or "hot bath," for which the female involved appears admirably attired and, after 150 years, definitely ready. But all of this still leaves us in complete goddesslessness, with only Willing Water to protect us against such summer demons as drought and diatoms. Not that he can't handle the job—but he's all for a goddess, too.

(*Continued on page 82 P&R*)

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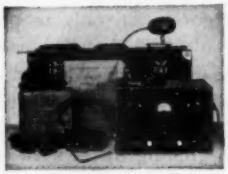

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Cyclopedia

To the Editor

In the Percolation and Runoff section of the April issue of the JOURNAL (p. *33 P&R*) you express reluctance to accept the subterranean hydrologic cycle of A. Leonard Davidson and you compare it with the fantastic concepts of dowser Henry Gross. In this stand you are quite right. However, your point that these are "new" theories requires some clarification.

The reverse, or subterranean, hydrologic cycle is the oldest concept of the hydrologic cycle and was generally accepted from the time of the Greeks to the first part of the 19th century, when the present, or pluvial, concept of the hydrologic cycle became universally accepted by scientific authorities.

In a paper on "The Birth and Development of Ground-Water Hydrology—A Historical Summary" which I prepared for the *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* (Vol. 41, p. 201, 1952), I presented an outline of the historical development of the hydrologic cycle. The outline pointed out that the early Greeks developed the concept of a subterranean hydrologic cycle. Due to the acceptance of the old Greek concepts by the Church as dogma, the writers of the Middle Ages, with the notable exceptions of such free thinkers as Leonardo da Vinci, concerned themselves with a variety of fanciful explanations on the operation of the subterranean cycle. The present concepts of Gross and Davidson bear a very close resemblance to, if not an identity with, the theories presented in the Middle Ages. Concerning Davidson's concept in particular it soon became apparent, even in the Middle Ages, that dissolved salt cannot be removed from sea water simply by filtration through earth materials but would require some means of distillation. This was accomplished in theory by employing a central fire which evaporated the sea water deep within the earth. Leaving the salt behind, the water vapor rose to the cooler mountain tops, where it condensed to moisture and appeared as springs or rivers.

For detailed descriptions of some of these medieval explanations of the hydrologic cycle I suggest consulting F. D. Adams, *The Birth and Development of the Geological Sciences,* Williams & Wilkins, Baltimore, 1938, pp. 426–460.

I offer this information only to point out that these so-called "new" concepts on the origin of underground water are merely rehashes of ancient and medieval theories subsequently discredited by scientific inquiry beginning in the 17th century. The results of the scientific investigations led to the acceptance by the 19th century of the pluvial, or rainfall, concept of the hydrologic cycle.

JAMES E. HACKETT

State Geological Survey Div.
Urbana, Ill.
May 20, 1954

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

ADMINISTRATION AND FINANCE

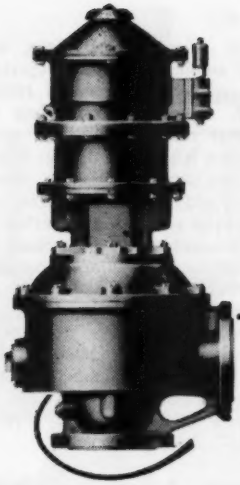
Taxation of Water Works Utilities in Ontario. W.W. Inf. Exch.—Can. Sec., AWWA, **8**:B:3:64 (Dec. '53, Jan. '54). In '52, legislation passed giving municipal councils in Ont. right to tax public utility properties. Wording of legislation given, together with tabulations of voluntary grants made to municipality, estd. value of water works system, assessed value, taxes paid in '52, yearly amt. paid by municipality other than for water supplied and fire protection, annual value of free water supplied to municipality, amt. paid to municipality in '51 in excess of debenture requirements, yearly amt. paid by municipality for fire protection, other information.—*R. E. Thompson*

Civil Defense and the Water Works System. J. R. MENZIES. Munic. Util. (Can.), **91**:10:31 ('53). In Canada, Dept. of National Health and Welfare assigned responsibility for guiding civil defense program. "Civil Defense Health Services Manual" published 2 yr ago. Three types of attack, popularly known as "ABC warfare" (atomic, biol., and chem.), in addn. to high-explosive and incendiary weapons. Local planning essential as conditions different in various potential target areas. One immediate effect of explosive attack is fracturing of services and consequent loss of water and reduced pressure, necessitating isolation. Generally agreed that there will be little damage to underground distr. system by atomic air burst. In winter, with deep frost penetration, draining of isolated areas might be necessary to prevent freezing. In event of attack, few, if any, water works personnel will be able to render independent decisions regarding potential danger from radioactivity. Monitoring teams being trained. In general, unlikely that air bursts will render water supply unsafe due to radioactivity. Considerable danger from gross deterioration of sanitary qual., necessitating prompt warnings. Almost inevitable heavy fire damage may require pumping of contamd. water into system and use of emergency supplies for human consumption. Displacement of pop. may overload water supplies in reception areas. Difficulties in application of biol. warfare are deterrent to use. Also, maintenance of effective Cl residual throughout distr. system will go far toward minimizing or eliminating danger—secondary points of application may be necessary. Factor which reduces likelihood of use of chem. is that large amts. are required in relation to small proportion of water actually used for human consumption. Possible interference with qual. of supply indicated by sudden increase in turbidity, O consumed, or Cl demand, or by abnormal variations in pH or alky., should be investigated immediately. Of primary importance, are location and availability of plans of water and sewerage systems. Absolute min. is duplicate copies outside target area, in addn. to those at headquarters. Also dependence on knowledge and memory of one official hazardous. Author suggests need for addnl. trained personnel. Likelihood of disruption of elec. power supply must be considered.—*R. E. Thompson*

Water Rates, Canadian Cities. W.W. Inf. Exch.—Can. Sec., AWWA, **8**:B:1:1 (Oct. '52); **8**:B:2:62 (Mar. '53). Detailed schedules of rates.—*R. E. Thompson*

Port Hope Water Rates Case. W.W. Inf. Exch.—Can. Sec., AWWA, **8**:D:1:1 (Dec. '53). Schedule of rates issued by Port Hope, Ont., Water Works Com. provided for 4 classes of consumers: [1] domestic, [2] coml. and industrial, [3] those supplied through 1 meter for benefit of more than 1 tenant, and [4] those outside municipality. Plaintiff, owner of bldg. occupied by number of tenants supplied through 1 meter, claimed overcharge because assessed rates were do-

(Continued on page 64)



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ONE 4-INCH CONNECTION to your main pipe line...

PREVENTS *surge rupture vacuum collapse*

Why take chances? No matter what the safety factor, surge and hammer can play some dirty tricks . . . rupture lines, blow out packing, fracture valves. And if the line breaks or is drained rapidly, it can collapse from vacuum.

Simplex Type CCAV is a new combination! A controlled-closing and vacuum-breaking valve to protect your lines against both of these dangers. It's easily installed, moderately priced, positive-acting.

When lines are being filled, Type CCAV Valve vents air to prevent binding, controls transfer time to prevent surge damage. Timing can be quickly set from a few seconds up to well over ten minutes—as dictated by site requirements. If hammer is excessive, Type CCAV automatically discharges water . . . extra protection for costly lines and fittings.

When lines are subject to collapse from rapid draining or line breaks, the Simplex CCAV acts quickly . . . breaks the vacuum for maximum safety.

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(*Continued from page 62*)

mestic and not lower rate applicable to coml. and industrial consumers. To Jan. '50, some of tenants had been domestic, but since that date all had been coml. Judge dismissed action on grounds that Class 3 relieves commission of necessity of examining into nature of occupancy in premises served by 1 meter; also, use of 1 meter for several tenants deprives commission of benefit of min. charge applicable in respect to each tenant if there were separate meters. Since dispute occasioned by vagueness of rate schedule, no order made as to costs.—*R. E. Thompson*

The Rate Structure Problem. H. KAHREL. Water (Neth.), **37**:282 ('53). Author discusses rates and rate structures in US and concludes that similar problems exist in Holland. Complications of nonremunerative extensions are common. National, provincial, and municipal govts. aid in all possible ways where customers are unable to finance extensions. Article 281 of municipal laws states that improved or unimproved real estate situated in certain sections of municipality can be taxed yearly for max. period of 30 yr. Usually benefit tax, in addition to equal amount for each property, consists of sum related to proceeds realized from property. Supreme court has repeatedly stated that real estate parcel can only be taxed when it actually derives benefit. It is difficult to decide borderline cases. Some municipal ordinances for benefit taxes cover all improved real estate whether individual parcels connected or not, because of greater fire protection from adjacent connected property. There is also question whether or not citizens who have no property are benefited by improvements. Moreover, amount levied is related to required loans necessary for work and is not percentage of increase in value. Commission has been formed to study rate structures and develop procedures.—*W. Rudolfs*

Assessment Action at Belleville, Ont. ANON. W.W. Inf. Exch.-Can. Sec., AWWA, **8**:D:2:4 (Mar. '54). In '52, Ontario municipalities given right to tax public utility properties. Belleville Public Utilities Com. properties assessed at $170,830, only

(*Continued on page 66*)

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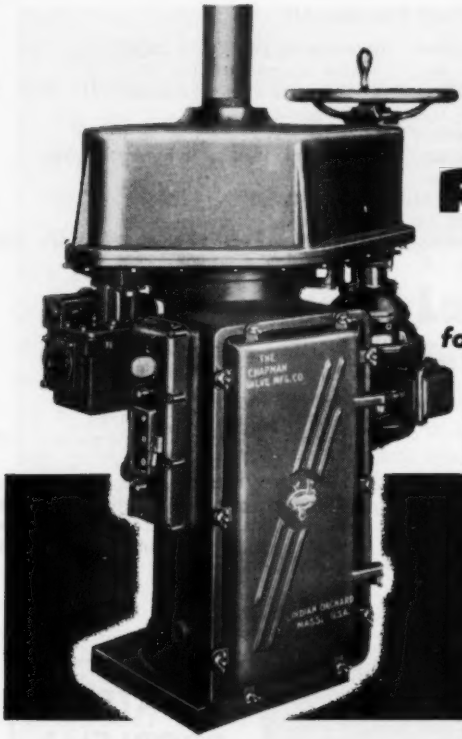

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Simple, durable mechanism of Chapman's Motor Unit. Handwheel remains stationary during motor operation.

Chapman Motor Units have fewer components than any other units, providing greater dependability, much lower maintenance costs.

There are only two pinions and two gears in the motor reduction train: drift is eliminated and lash is negligible. Your valves seat tight, but not too tight. Operation is *always* smooth and trouble-free.

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Weatherproof and steam tight, Chapman's floorstand units are shipped completely wired, ready to connect to your power leads, for easy, rapid installation. This modern motor unit is dependable and economical. Send for *new* catalog No. 51.

The CHAPMAN Valve
Manufacturing Company
INDIAN ORCHARD, MASSACHUSETTS

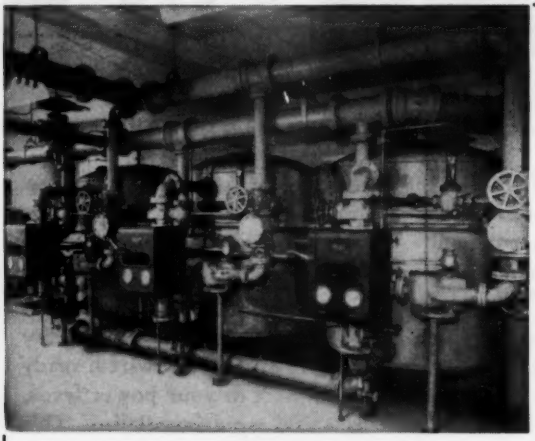
(*Continued from page 64*)

$63,761 being acceptable to commission, which claimed that standpipe, reservoir, etc., should be considered equip. and not bldgs. Accordingly, court action instituted. In Jan. '54, commission decided to withdraw action and pay taxes, despite advice of solicitor, who as result resigned. Since then taxes on underground storage reservoir, mixing and settling basins, and filters paid, but by agreement with city council, standpipe ($16,560) excluded from assessment.—*R. E. Thompson*

ANNUAL REPORTS

Community: **Atlanta, Ga.**
Reporting organization: Water Dept.
Year ending: Dec. 31, '51
Population served: 400,000
Customers: 83,518
No. of employees: 431
Source of supply: Chattahoochee R.
Type of treatment: coagulation, sedimentation, filtration, chlorination
Water produced (mil gal): 20,731
Water sold (mil gal): 16,585
Water unaccounted for (%): 17.7
Consumption (mgd): max.: 73; avg: 57 (95 gpcd)
Metered services (%): 98+
Mains (mi): distr. and trans.: 1,004
Valves: 11,427
Hydrants: 7,394
Distr. storage (mil gal): 2.5
Revenue ($): water: 4,869,820; other: 702,073; total: 5,571,893
Expense ($): 1,471,004
Income ($): 4,100,889
Bond interest ($): 122,974
Bond retirement ($): 303,241
Capital outlay ($): 1,615,914
Paid to general fund ($): 2,058,760
Debt outstanding ($): 5,708,000
Unit costs ($/mil gal): chemicals: 3.22; high-lift pumping: 8.81
Treated-water analysis (ppm): silica: 9.0; alky.: 15.5; chloramine residual: 1.0; dissolved solids: 25; hardness: 20; iron: 0.02; calcium: 7.6; sulfates: 4.0: chlorides: 3.0; magnesium: 1.5; pH: 8.7

(*Continued on page 68*)



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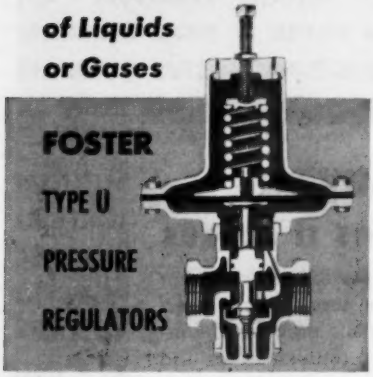

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835 LEHIGH AVENUE UNION, N. J.

AUTOMATIC VALVES
SAFETY VALVES • FLOW TUBES

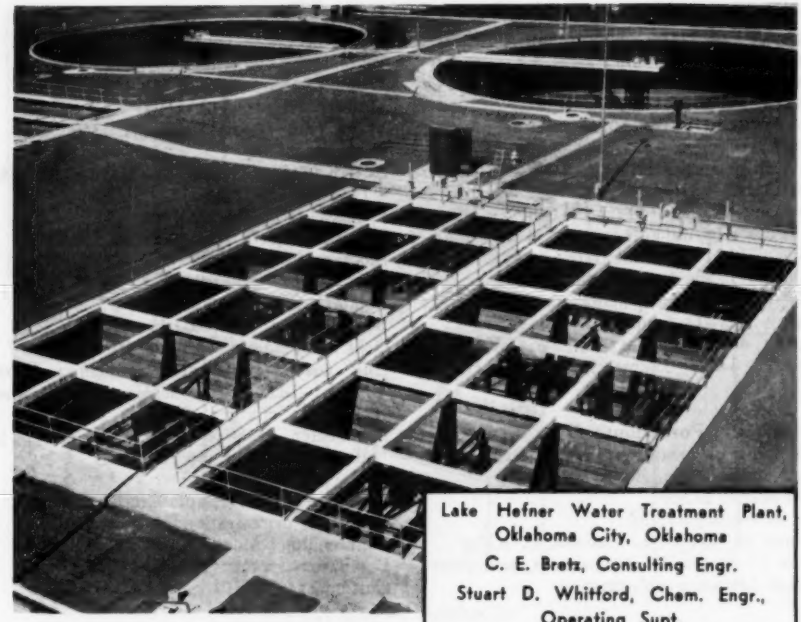
(*Continued from page 66*)

Accident statistics: injuries: 75; lost time (man-days): 403 (0.36%).

Community: **Atlanta, Ga.**
Reporting organization: Water Dept.
Year ending: Dec. 31, '52
Population served: 430,000
Customers: 88,204
No. of employees: 453
Source of supply: Chattahoochee R.
Type of treatment: coagulation, sedimentation, filtration, chlorination
Water produced (mil gal): 19,832
Water sold (mil gal): 15,865
Water unaccounted for (%): 19
Consumption (mgd): avg: 54 (108 gpcd)
Metered services (%): 97
Mains (mi): distr. and trans.: 1,090
Valves: 12,396
Hydrants: 8,072
Distr. storage (mil gal): 2.5
Revenue ($): water: 4,496,332; other: 454,-122; total: 4,950,454
Expense ($): 1,587,409
Income ($): 3,363,045
Bond interest ($): 160,035
Bond retirement ($): 288,241
Capital outlay ($): 3,061,329
Paid to general fund ($): 2,339,363
Book value ($): 50,000,000
Debt outstanding ($): 6,937,000
Unit costs ($/mil gal): high-lift pumping: 8.75; chemicals: 2.87
Treated-water analysis: see 1951 report above
Accident statistics: lost time (man-days): 383 (0.32%).

Community: **Erie, Pa.**
Reporting organization: Bureau of Water
Year ending: Dec. 31, '51
Population served: 150,000
Customers: 33,526
Source of supply: L. Erie
Type of treatment: coagulation, sedimentation, filtration, chlorination
Water produced (mil gal): 13,568
Consumption (mgd): max.: 53; avg: 37 (247 gpcd)
Metered services (%): 5.26
Mains (mi): distr. and trans.: 344
Valves: 5,229
Hydrants: 1,867
Distr. storage (mil gal): 44.1
Revenue ($): water: 1,167,067; other: 56,-963; total: 1,224,030

(*Continued on page 70*)



Lake Hefner Water Treatment Plant, Oklahoma City, Oklahoma

C. E. Bretz, Consulting Engr.

Stuart D. Whitford, Chem. Engr., Operating Supt.

Thirty-six paddle flocculation units installed in 2 tanks each 92'x36'x14'. Two pier supported center drive circular collectors in 100' diameter tanks.

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Call upon Walker Process for recommendations and assistance on your next water treatment project.

WALKER PROCESS

WALKER PROCESS EQUIPMENT, INC.

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Aurora, Illinois

(*Continued from page 68*)

Expense ($): op. and maint.: 821,663; depn.: 222,843; total: 1,044,506
Tax paid (% of revenue): none
Income ($): 179,524
Bond interest ($): 38,074
Bond retirement ($): 95,000
Paid to general fund ($): 79,097
Book value ($): 16,879,643
Debt outstanding ($): 1,196,000
Unit costs ($/mil gal): water: 0.221; pumping: 22.14; treatment: 7.78; admin.: 14.70; distr.: 13.93; total operating items: 76.98
Raw-water analysis (ppm): turbidity: 3–22; alky.: 88–91; temp. (°F): 35–73
Rates: domestic: flat; industrial (¢/1,000 gal): 6–20; commercial (¢/100 cu ft): 4.5–17.

Community: **Portsmouth, Va.**
Reporting organization: Water Dept.
Year ending: Jun. 30, '52
Customers: 27,957
No. of employees: 52
Source of supply: L. Cahoon, L. Kilby
Type of treatment: coagulation, sedimentation, filtration, chlorination
Water produced (mil gal): 4,189
Water sold (mil gal): 3,645
Water unaccounted for (%): 13
Metered services (%): 100
Mains (mi): distr. and trans.: 346
Hydrants: 1,426
Revenue ($): water: 853,333; other: 74,713; total: 928,046
Expense ($): 553,557
Tax paid (% of revenue): 4.3
Income ($): 374,489
Debt service ($): 39,071
Capital outlay ($): 282,408
Book value ($): 6,200,045
Debt outstanding ($): 262,000
Unit costs ($/mil gal): pumping: 18.60; purif.: 12.80; debt service: 8.70; other operating charges: 99.40
Raw-water analysis (ppm): turbidity: 5; alky.: 10; color: 8; pH: 6.3.

Community: **Liverpool, England**
Reporting organization: Water Dept.
Year ending: Mar. 31, '52
Population served: 1,056,105
Customers: 324,310

(*Continued on page 72*)

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Type SM Limitorque operating 48" butterfly valve.

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LimiTorque is self-contained and is applicable to all makes of valves. Any available power source may be used to actuate the operator: Electricity, water, air, oil, gas, etc.

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except for the very largest diameters, can be handled easily without the use of cranes or other machinery. In many cases, two men can pass a length to the men in the trench or lower it by ropes. Thus the light weight of this modern asbestos-cement pipe effects many savings in labor and transportation costs, and materially speeds completion of the line.

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(*Continued from page 70*)

Source of supply: surface and ground water
Type of treatment (surface supplies): filtration, lime
Water produced (mil gal *): 17,527
Water sold (mil gal *): 16,683
Consumption (mgd): max.: 57; avg: 48 (45 gpcd)
Hydrants: 22,788
Revenue (£): 979,458
Expense (£): 445,548
Income (£): 533,910
Treated-water analysis (ppm): hardness: 17–41; total solids: 37–82; pH: 6.8–7.0; of 318 samples collected from distr. sys., 99.7% showed absence of *Esch. coli*
Rates: industrial (d.†/1,000 gal *): 10.

* Imperial gallons.
† Pence.

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Seattle Gravity Supply Meets Metropolitan Growth Needs. R. W. Morse. W.W. Eng., **107**:400 (May '54).

Oklahoma City System Expanded to Meet Metropolitan Growth. M. B. Cunningham. W.W. Eng., **107**:408 (May '54).

How Des Moines Has Maintained Safety Factor in Its Supply. D. L. Maffitt. W.W. Eng., **107**:410 (May '54).

New Prestress Method for Biggest Water Tank. Anon. Eng. News-Rec., **152**:20:32 (May 20, '54).

Subsoil Stabilization Saves 40-Year-Old Reservoir. W. B. Johnson. Am. City, **69**:5:122 (May '54).

Eleven Texas Cities Join in Giant Pipeline and Dam Project. B. H. Cruce. Pub. Wks., **85**:4:75 (Apr. '54).

Underground Water Pollution by Oilfield Brines. C. B. Johnston. Pub. Wks., **85**: 4:93 (Apr. '54).

Selection of Main Line Meters Simplified by Use of Charts. J. C. Thoresen. Wtr. & Sew. Wks., **101**:150 (Apr. '54).

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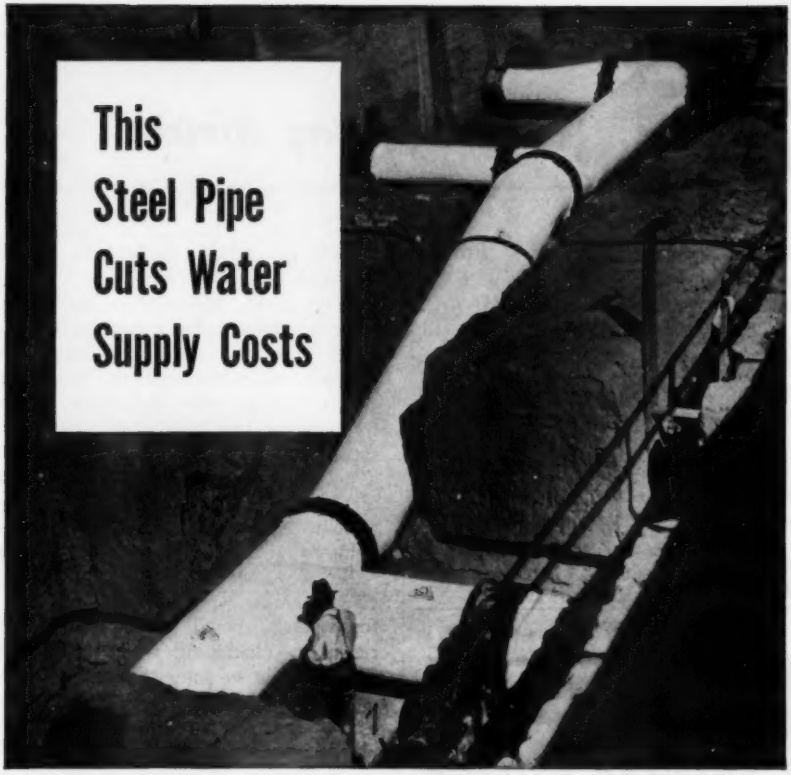

Many waterworks men have found they get improved efficiency by using Armco Welded Steel Pipe for water supply and force mains.

There is little or no loss from leakage. Strong tight joints can be made with standard couplings or by field welding. A smooth, spun enamel lining prevents tuberculation and assures continued high flow capacity.

Armco Steel Pipe also has a high strength-to-weight ratio that withstands internal or external pressures. It flexes with the load to guard against explosive bursting due to vibration or sudden overload.

You'll find Armco Pipe easy to handle and install. Jobs go fast and costs are low. Diameters of Armco Pipe range from 6 to 36 inches with wall thicknesses from 9/64- to ½-inch. Write for complete information. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1284 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

ARMCO WELDED STEEL PIPE

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The Reading Meter

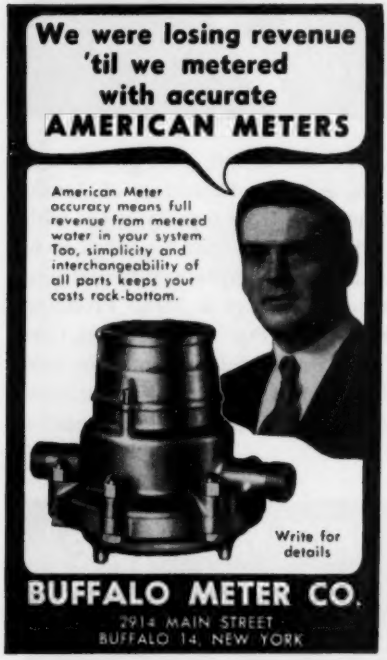
The Challenge of Man's Future. *Harrison Brown. The Viking Press, New York (1954) 290 pp.; $3.75*

A sobering parade of analysts have been warning that standards of living are determined—putting aside inequalities in distribution—by dividing the world's goods and resources by the number of people who must share them. Few have assembled so brilliant an array of statistics, however, or have so directly faced up to the unpleasant social implications as the geochemist responsible for this study.

With great objectivity—but without detachment, as befits a humane observer—Mr. Brown assesses the host of impending calamities that the world now shows little promise, inclination, or ability to avert, and concludes that if we do escape them, the further achievement of a lower birth rate might stave off complete catastrophe. Granted world peace, political stability, and a level of technology that is not only uniform throughout the world but also high enough to circumvent the prospective shortages of fossil fuels, metals, and certain other resources (including water), this earth may be able to support a population of 50 billions, although such amenities of space and consumption as lawns and fireplaces would have to be sacrificed. The exact number, of course, is of less importance than the pitiless fact that there *is* a maximum.

And to stumble against any of the obstacles that confront us would mean immediate disaster. Mr. Brown pointedly observes that machine civilization is highly vulnerable to disruption, and that, once destroyed, even the survival of technical knowledge might not permit a new start, for the earth has been stripped of those natural facilities which fostered its original development: rich, easily worked ores of copper and iron; surface outcroppings of coal; extensive forests; naturally fertile soils. In this environment and with these prospects, "muddling through" is suicide for our species—or at least cultural extinction. There has been no lack of warning.

(*Continued on page 76 P&R*)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First in the field of cathodic protection, HARCO provides complete job-engineered systems or contract installations.

Job-engineered systems include all necessary testing, drawings, materials and installation . . . as well as optional periodic maintenance services.

In contract installations, experienced field teams use customers' specifications. HARCO engineers can handle as much or as little of the total job as required.

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THE *Harco* CORPORATION

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The Reading Meter

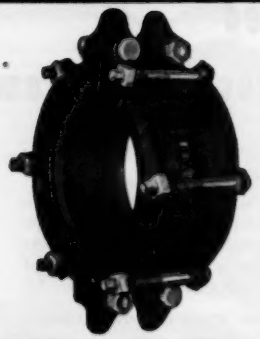
(Continued from page 74 P&R)

Cathodic Protection of Pipelines and Storage Tanks. *V. A. Pritula. Translated from the Russian. Dept. of Scientific & Industrial Research, 5–11 Regent St., London, S.W.1, England (1953) 160 pp.; boards; $2.25 US from Her Majesty's Stationery Office, Box 569, London, S.E.1, England*

This Russian monograph, originally published in 1950 by the Chief Petroleum Marketing Organization of the (Russian) Ministry of the Petroleum Industry, is recommended by Britain's Dept. of Scientific and Industrial Research as a practical manual and also as a textbook. After a brief introduction which indicates that Russia has about as much water pipe in the ground as the US (more than 20,000,000 tons, as opposed to a US estimate of 24,000,00 tons), the author discusses the basic design and necessary calculations for cathodic protection systems. A chapter is included on galvanic anodes, largely devoted to alloys of zinc, magnesium, and aluminum, with the preference given to the latter. One interesting feature of Russian practice is the use of wind generators to power remote stations of cathodic protection systems along long oil pipelines. As with most of the principles discussed, the idea is also applicable to long transmission lines for water. The author concludes that, if cathodic protection is applied in time, the service of a pipeline or tank can be extended by at least 20 years.

(Continued on page 78 P&R)

FOR REPAIRING BROKEN MAINS



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STEEL PIPE helps cut cost of Philadelphia's long-range program of waterworks improvement

The tracks you see in the photo below are part of the Pennsylvania Railroad's main line. That's one reason why the pipes passing under the tracks are built of strong, *electric welded steel.*

Engineers know from experience that Alco Electric Welded Steel Pipe has the strength and resilience to absorb vibration, impact and overloading that destroy pipe of other types. They know, too, that Electric Welded Steel Pipe offers still other advantages that help cut piping costs. For example: *Efficiency*—smooth, tar-enameled inside surface gives excellent rate of flow. *Economy*—not only is first cost low but sections are long and light, for fast, easy installation. And *durability*—estimated life is 75 to 100 years.

Alco makes Electric Welded Steel Pipe to meet AWWA and other specifications. Forty-foot lengths fabricated without girth seams in diameters of 30 in. and above. Under 30 in., lengths of 22 ft furnished without girth seam, or 40-ft lengths with one girth seam. Diameters range from 20 in. to 120 in.

Use Alco Electric Welded Steel Pipe for your piping projects. Your nearest Alco Products Sales Representative will be happy to furnish you complete technical information and to discuss with you any special problems you may have.

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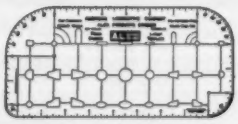
PHILADELPHIA used efficient, durable Alco Electric Welded Steel Pipe in diameters of 60, 54 and 48 in., with thicknesses of ½ and ⅜ in. Sections are joined with Dresser couplings.



For information on how to obtain one of these handy Alco Piping Templates, write to your nearest Alco Products Sales Office.

ALCO PRODUCTS

AMERICAN LOCOMOTIVE COMPANY

Sales and Service Offices In Principal Cities

The Reading Meter

(*Continued from page 76 P&R*)

Water Softening. *Catalog of Technical Reports (CTR) 107. Office of Technical Services, Business and Defense Services Administration, US Dept. of Commerce, Washington 25, D.C. (1954) 5 pp.; paperbound; 10¢*

Most of these technical reports are in German and deal with German developments and practice, but there are also some English-language studies.

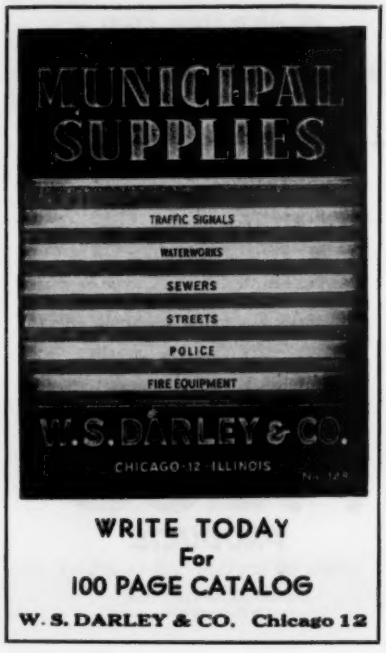
Chemical Character of Surface Waters of Kentucky, 1949–1951. *William L. Lamar & Leslie B. Laird. Agricultural and Industrial Development Board of Kentucky, Frankfort, Ky. (1953) 143 pp.; paperbound; $1*

Water temperature, color, specific conductance, pH, and chemical analyses are included in this first report of a projected series, prepared cooperatively with the Geological Survey. A brief text discusses the significance of the various chemical and physical properties and also the general character of eight river basins in the region.

Through History With Standards. *American Standards Assn., 70 E. 45th St., New York 17, N.Y. (1954) 32 pp.; paperbound; free*

Selections from the history of standardization, succinctly told and wittily illustrated by mad cartoons, insanely captioned by literary quotations perverted from their original intent, but astonishingly apt. Highly entertaining and not a little instructive. One wonders, though, about the accuracy of that 45-in. arm of England's Henry I.

(*Continued on page 80 P&R*)



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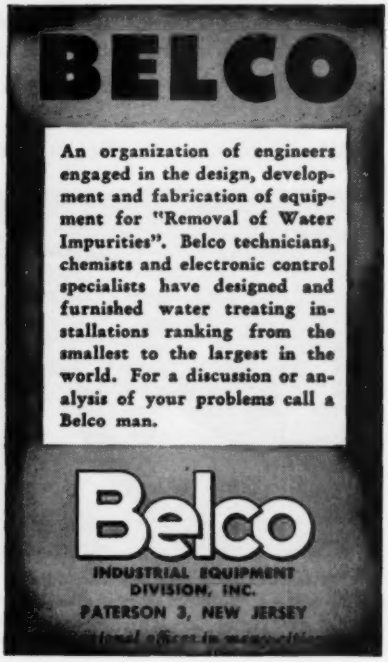
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Seattle boosts its water supply with 7 miles of *CONCRETE PIPE*

Westward from Lake Young, near Renton, Wash., this new concrete water line, shown in construction, extends seven miles to connect with Seattle's present system.

The job is the Seattle-Tacoma Airport Project. It required 1600 concrete pipe units of 60-in. diameter and 160 units of 72-in. diameter. Units are 21 feet long.

When you're planning any water line, large or small, specify concrete pipe for rugged strength, long service and proven economy. You'll get maximum hydraulic efficiency because there's no internal corrosion. Tight joints and dense structure prevent leakage and infiltration.

Look into the advantages concrete pipe affords. You'll find its first cost is moderate, it requires little if any maintenance and it lasts years longer. For taxpayers, who pay the bills, that's real ***low-annual-cost*** water-line service.

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Independently Valved HYDRANTS
for non-freezing climates

Western water works engineers and fire chiefs were the first to approve Greenberg California-type fire hydrants. Now, after exhaustive tests, Underwriters' Laboratories, Inc., and Factory Mutual have confirmed your judgment.

Greenberg No. 74 and 76 hydrants are equipped with independent valves of a new type which open quickly and easily, allowing full flow with minimum resistance.

GREENBERG "CASCADE"
BASE-VALVE FIRE HYDRANTS for freezing climates are also approved by Underwriters' Laboratories, Inc., in 4½" and 5" size inlet valve openings.

Other innovations such as you would expect of this 100-year-old firm who evolved the California-type hydrant are shown in the free booklet "Hydrants by Greenberg." May we send you a copy?

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The Reading Meter

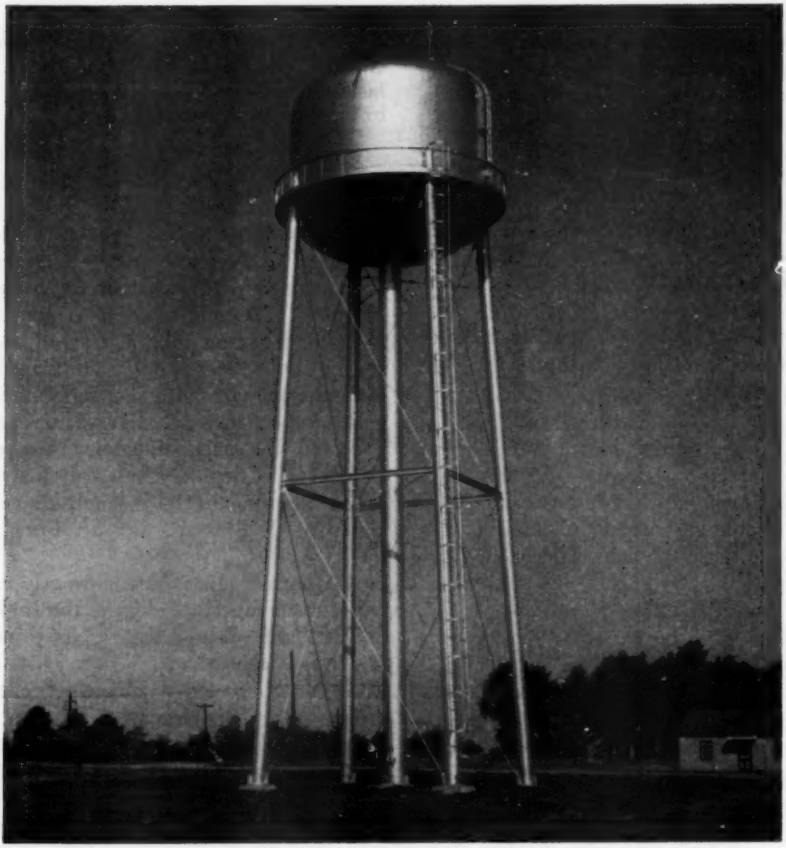
(Continued from page 78 P&R)

European Conference on Health Education of the Public: *April 10–18, 1953. Regional Office for Europe, World Health Organization, Palais des Nations, Geneva, Switzerland (1953) 58 pp.; paperbound; free to libraries, health institutions*

The observation is made in the course of the conference reported by this book that health education is one of the best defenses against charlatanism. The fact is self-evident, but the word is a strong one, and therefore limiting. Ignorance itself produces far more damage than venal quackery.

Before the water worker decides he has no professional interest in this subject, let him ask himself whether life would not be pleasanter if he did not have to assure people that neither the chlorine, the lime, nor the alum that he puts in their water on the one hand; nor the hardness that he fails to remove on the other, is responsible for their ailments—whether disease-caused, psychosomatic, or neurotic. How about some magic that would add conviction to the mere technical assurances that fluorides in water do not cause feeblemindedness, delinquency, cancer, or communism? Or persuade the metal-plater that traces of cyanides or cadmium in his shop wastes really can kill fish and maybe even people?

To return to this conference, however, it is entirely possible that, if held in this country, the emphasis would have been completely different. Much of what passes for health education in the US offers no antidote to ignorance, and, it might be argued, does far more harm than good. If we cannot obtain the right kind of education in the flood of printed matter—both advertising and editorial—devoted to health, then it might be better to have none of it. Certainly we should have fewer newspaper and magazine panaceas that torture the afflicted with dishonest half-truths. Our educational level will rise automatically, once these dramatic distortions are removed.



Progress in The South

This 100,000-gal. Horton ellipsoidal-bottom elevated steel tank was installed at Jackson, S. C., to provide dependable gravity pressure in their water distribution system.

Horton elevated steel tanks provide an economic means of meeting peak loads in water systems, and also serves as a reliable reserve for fire protection. Write our nearest office for estimating figures or additional information on Horton elevated tanks, reservoirs or standpipes.

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In Canada—HORTON STEEL WORKS, LIMITED, FORT ERIE, ONT.

(*Continued from page 54 P&R*)

A. P. Black has been named to organize and direct a Bureau of Water Research at the University of Florida. The Bureau, which is to be activated in July of 1955, will have as its function the continuous study of the water resources of Florida, including the assembly of data on quantity, recharge, pollution, and methods of treatment and analysis. In order to head the new enterprise, Dr. Black, who was president of AWWA in 1950, will step down as chairman of the university's Dept. of Chemistry.

Its centennial is being celebrated by Barrett Div., Allied Chemical & Dye Corp., which dates its origin from the roofing business established by Samuel E. Barrett in Chicago in April 1854.

The why of wives is as simple as H_2O in Southeast Asia, according to an official quoted in a recent publication of the World Health Organization as follows:

We have in one area here some wells which furnish water indispensable to life but which are 13 to 14 kilometers [about 9 miles] distant from the community. A wife can make only one trip a day to fetch the necessary water, which she carries in a bucket. This quantity of water is quite insufficient for the needs of a husband. The only solution, therefore, is to have more than one wife.

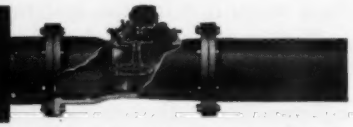
And you think your distribution system gives you trouble! Or troubles!

Wentworth Smith, general sales manager of Neptune Meter Co., has been named vice-president in charge of sales. He is succeeded as general sales manager by John J. Carroll, formerly Louisville, Ky., district manager. The changes are part of a reorganization of the firm's sales division which followed the acquisition by Neptune of Revere Corp. of America, instrument manufacturer, its subsidiaries, and Cox & Stevens Aircraft Corp.

William C. Renshaw, formerly engineer and superintendent of the Inglewood, Calif., Water Dept., has joined the Las Vegas, Nev., Water Dist. as its general manager and chief engineer. The District was formed to bring Lake Mead water to Las Vegas, and Renshaw will supervise the necessary transmission line construction, as well as arranging to take over the water system from the Las Vegas Land & Water Co., which is a subsidiary of the Union Pacific railroad.

(*Continued on page 84 P&R*)

IT PAYS TO SAY
BUILDERS PROPELOFLO



THE MAIN LINE METER manufactured to Builders' traditional quality-standards. Accuracy is within 2% over a wide range. Low loss-of-head. As easy to install as a valve or fitting. For Bulletin 380-K4, write Builders-Providence, Inc., 365 Harris Ave., Providence 1, R. I.

- More power and accuracy from Venturi body design
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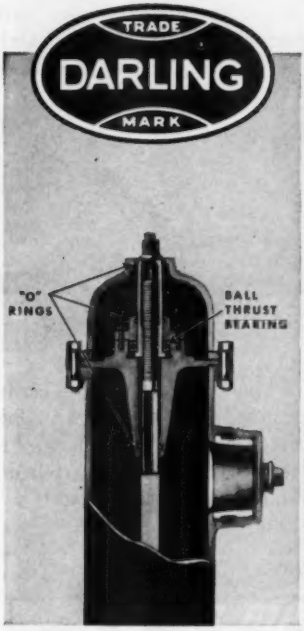


A. W. Grathwol, manager of the Sandusky, Ohio, Water Distribution Department, checking static water pressure on a newly installed Darling B-50-B hydrant.

Word is getting around about DARLING'S NEW B-50-B FIRE HYDRANT

WATER distribution men like A. W. Grathwol of the Sandusky, Ohio, Water Distribution Department, are spreading the good news about the new patented Darling B-50-B fire hydrant. It rates as the most important fire hydrant advance in 50 years.

Here are reasons why . . .

1. The "O" ring seals eliminate need for a stuffing box. Darling's B-50-B is a packless, *dry-top* hydrant that saves service time and trouble. It does away with bothersome packing gland adjustment and maintenance, assures constant lubrication of the operating threads *and prevents water from reaching the operating threads.*

2. The Darling B-50-B is a *ball-bearing* operated hydrant. Opening and closing takes less than half the usual wrench torque.

And you also get another long-time advantage of Darling hydrants . . . all inside working parts, including the main valve seat and drain valve seats, can be removed through the top *by one man* for on-the-spot inspection and maintenance. Write for Bulletin No. 5007 before you decide on any hydrant. Address . . .

DARLING VALVE & MANUFACTURING CO.

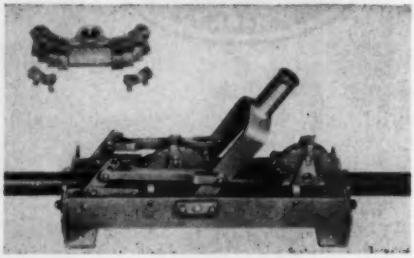
Williamsport 23, Pa.

Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ontario

(Continued from page 82 P&R)

Mathiesen Chemical Corp. and Olin Industries, Inc., are submitting a merger proposal to their stockholders. If accepted at special meetings to be held June 29, the resulting firm will bear the name Olin Mathieson Chemical Corp. In addition to its output of industrial chemicals, including chlorine and hypochlorites, Mathieson is a producer of agricultural chemicals, petrochemicals, and, through its E. R. Squibb & Sons Div., pharmaceuticals. Olin Industries produces metals and fabricated parts, industrial explosives, firearms and ammunition, cellophane, polyethylene, and other products. The two firms have already collaborated in the formation of the jointly owned Matholin Corp., producer of the chemical hydrazine.

A pipe pulling or pushing innovation is the new gripping dog with replaceable teeth, shown separately, below, and as installed in the Model



B Pipe Puller or Pusher of Trojan Mfg. Co., 1202 Race Dr., Troy, Ohio. The Model B can take pipe up to 2 in. in diameter and offers three pushing speeds for different types of soils.

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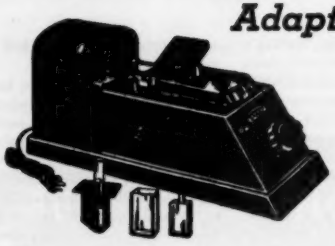

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

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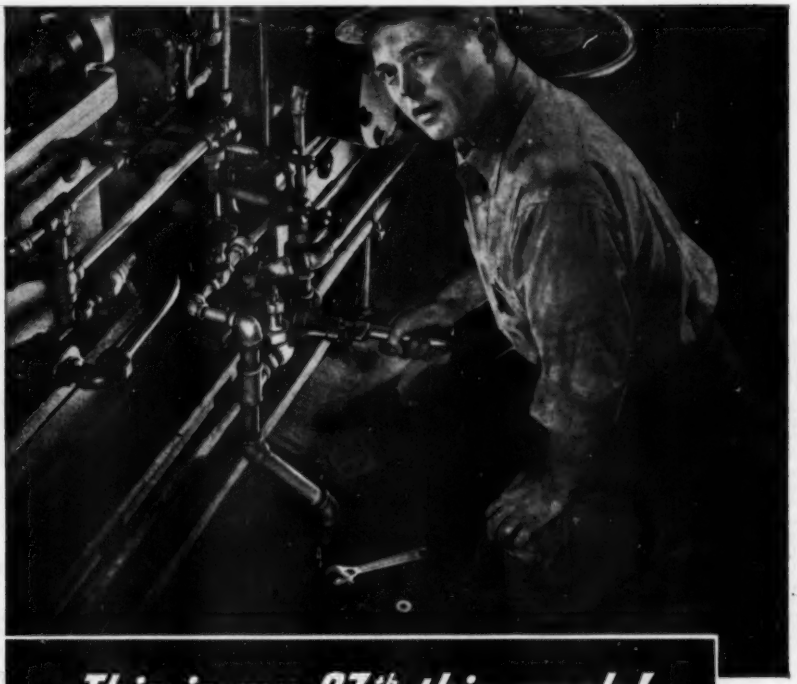

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Most of your valve repair jobs are simple—a few minutes here, an hour or so there. But it's the way they add up that counts. For if your plant is typical, you can number your valves by the hundreds—or even thousands.

You have to figure a certain amount of valve maintenance, of course. However, there is a limit to what's reasonable—and there is a way to hold to it.

Here's where thrifty buying comes in—buying better quality valves and fittings in the first place—buying known dependability instead of a bargain and a promise. And it's Crane that offers the opportunity for thrifty buying . . . with a piping equipment line of highest quality and suitability.

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Applications received May 1–31, 1954

Adcock, Robert T., Water Utility Inspector, Castroville County Water Dist., Box 33, Castroville, Calif. (Apr. '54) *MRPD*

Albuquerque Dist. Corps of Engrs., Box 1538, Albuquerque, N.M. (Munic. Sv. Sub. Apr. '54) *RPD*

Andersen, Burton L., Supt., Public Works & Water Dept., Box 400, Anchorage, Alaska (Apr. '54) *MPD*

Andrews, W. F., Sales Mgr., General Filtration & Engineering Ltd., 1546 Avenue Rd., Toronto, Ont. (Apr. '54)

Anthony, Roscoe L., Jr., Commercial Mgr., Central Div., Southern California Water Co., 16412 S. New Hampshire Ave., Gardena, Calif. (Apr. '54) *M*

Bacharach, Roy A., Water Supt., Box 28, Orofino, Idaho (Apr. '54) *MPD*

Bannister, J. A.; *see* Point Edward (Ont.) Public Utilities Com.

Barnes, Thomas P., Pres., Nebraska Construction Co., Farmer's State Bank Bldg., Lexington, Neb. (Apr. '54)

Benjamin, William L., Engr., Chief Water Engr.'s Office, Sec. of Pumping Station Efficiency, 811 N. Michigan Ave., Chicago 11, Ill. (Apr. '54)

Bergland, William A., Supt., Water Dept., Big Stone City, S.D. (Apr. '54) *MRP*

Bessemer Borough Council, Walter Ujcich, Water Comr., Bessemer, Pa. (Munic. Sv. Sub. Apr. '54) *M*

B-I-F Industries, Inc., George W. Kelsey, Vice-Pres., 345 Harris Ave., Providence 1, R.I. (Assoc. M. Apr. '54)

Birkinbine, William C., Maint. Supervisor, Bremerton Housing Authority, Box 631, Bremerton, Wash. (Apr. '54) *M*

Black, C. S., Treatment Plant Operator, Water Works, Eaton, Ohio (Apr. '54) *P*

Block, Burton S., Civ. Engr., Ripple & Howe, 833—23rd St., Denver, Colo. (Apr. '54) *RPD*

Bosworth, W. Nichols, Assoc. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *D*

Bridges, Howard Lee, Process Controlman, American Sugar Refining Co., Arabi, La. (Apr. '54) *MP*

Buell, George A., Supt., Water Dept., Windsor, N.Y. (Apr. '54) *MRPD*

Builders-Pacific, Inc., L. H. Chamberlain, Pres., 1036 University Ave., Berkeley 2, Calif. (Assoc. M. Apr. '54)

Bullard, William E., Jr., Forester, US Forest Service, Box 4137, Portland 8, Ore. (Apr. '54) *R*

Butter, Robert; *see* Owen Sound (Ont.) Public Utilities Com.

Campbell, Ronald J., San. Supervisor, Orinoco Mining Co., Apt. 3, Bolivar, Venezuela (Apr. '54) *MRPD*

Cavotti, M. A., Pres., Leaside Contracting Co. Ltd., 9 Densley Ave., Toronto 15, Ont. (Apr. '54)

Chamberlain, L. H.; *see* Builders-Pacific, Inc.

Chenoweth, R. G., Water Comr., 1200 Coburn, Worland, Wyo. (Apr. '54) *M*

Cobb, S. H., Gen. Foreman, Water Distr., Water Dept., 1000 Main St., Jacksonville, Fla. (Apr. '54) *D*

Cooper, Charles C., Jr., Asst. Gen. Counsel, Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *R*

Coquitlam, Corp. of the Dist. of, Harry F. Hockey, Eng. Supervisor, 1111 Brunette St., New Westminster, B.C. (Munic. Sv. Sub. Apr. '54) *MD*

Cottrell, Gerard J., San. & Industrial Hygiene Engr., 3380th USAF Hospital, 3380th Tech. Training Wing, Keesler Air Force Base, Miss. (Apr. '54) *MRPD*

Criner, Carlos A., Dentist, School Health Dept., Ministerio de Educacion, Box 705, Havana, Cuba (Apr. '54) *RP*

Crowley, Frank W., Asst. Water Works Engr., Kuala Lumpur, c/o P.W.D. Water Works Office, Brockman Rd., Kuala Lumpur, Malaya (July '54) *MPD*

Davis, Fred M.; *see* Rose City (Ore.) Water Dist.

DeJong, G. Edward, Owner, Middaugh, DeJong & Assocs., 509 Empire Bldg., Rockford, Ill. (Apr. '54) *RPD*

Dennis, Frederick B., Gen. Mgr., California Filter Co., Inc., 156 Spear St., San Francisco, Calif. (Apr. '54) *P*

Dewart, Donald M., San. Engr., Wiley & Wilson, 2179 Carrington Rd., Lynchburg, Va. (Apr. '54) *P*

Dixon, Givens; *see* Henderson (Ky.) Water & Sewer Com.

Eberhart, F. B., Supt., West Virginia Water Service Co., Montgomery, W.Va. (Apr. '54) *M*

Emigh, Frank D., Mech. Elec. Engr., Dept. of Public Utilities, Water Div., Administration Bldg., Box 1639, Tacoma, Wash. (Apr. '54)

Fairmount Water Works, Ralph E. Parker, Supt., Fairmount, Ind. (Corp. M. Apr. '54) *MP*

Fircrest, Town of, George Masko, Supt., 115 Ramsdell St., Tacoma 66, Wash. (Munic. Sv. Sub. Apr. '54) *MRD*

Flemming, C. V., Field Engr., International Water Supply Ltd., 12 Maitland St., London, Ont. (Apr. '54)

Gable, Joseph W., Supt., Water Dept., 151 Walnut St., Pontiac, Mich. (Apr. '54) *MR*

Gleason, Robert J., Director, San. Eng. Div., Dist. Public Works Office, 13th Naval Dist., Bldg. 8, Pier 90, US Naval Station, Seattle 99, Wash. (Apr. '54) *MP*

Gordon, Spiro G., Civ. Engr., Bureau of Water, Dept. of Water & Sewers, 402 City Hall, Chicago, Ill. (Apr. '54) *MRPD*

Goudey, A. S., Vice-Pres., Boston Water Purifier Co., 40 Murray St., New York 7, N.Y. (Apr. '54) *MRPD*

Greater Nanaimo Water Dist., C. F. Newcombe, Chief Comr., 437 Fitzwilliam St., Nanaimo, B.C. (Corp. M. Apr. '54) *MRPD*

Gresham, Roy M.; *see* Princeton (Ky.) Water & Sewer Dept.

Gunny, Robert R., Asst. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *RD*

Gupta, Bhagwat P., Supt., Water Works, Rajpur Rd., Dehra Dun. U.P., India (Apr. '54)

Haines, Fred S., Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *D*

Hancock, Robert M., Salesman, Western Utilities Supply Co., 525—9th Ave. S., Seattle, Wash. (Apr. '54)

Haynes, George D.; *see* Haynes, George, Co.

Haynes, George, Co., George D. Haynes, Owner, 4528 Main St., Kansas City 8, Mo. (Assoc. M. Apr. '54)

Hazlett, Merle O., Salesman, Neptune Meter Co., 1922 N. 21st, Boise, Idaho (Apr. '54) *MD*

Hencke, William, Sr. Station Engr., Dept. of Water Supply, Gas & Elec., 3201 Jerome Ave., Bronx, N.Y. (Apr. '54) *PD*

Henderson Water & Sewer Com., Givens Dixon, City Bldg., Henderson, Ky. (Corp. M. Apr. '54) *MRPD*

Herter, John C., Supt. of Utilities, Lindsborg, Kan. (Apr. '54) *MRD*

Hill, William J., Salesman, Western Utilities Supply Co., 1905 N. Williams Ave., Box 7784, Portland, Ore. (Apr. '54) *MRPD*

Hines, Troy M., Filter Plant Supt., Box 264, Forest Grove, Ore. (Apr. '54) *P*

Hockey, Harry F.; *see* Coquitlam (B.C.)

Hopkins, George E., Civ. Engr., Water Div., 3628 S. 35th, Tacoma, Wash. (Apr. '54) *M*

Hunter, Hugh R., Water Plant Operator, 201 E. Court St., Montpelier, Ohio (Apr. '54) *P*

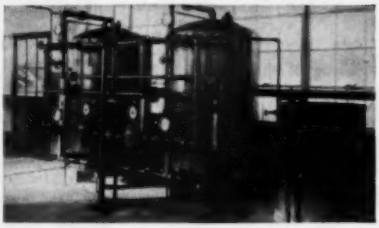
(*Continued on page 88 P&R*)

Roberts Filter *means...*

MUNICIPAL WATER PURIFICATION

The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

INDUSTRIAL WATER RECTIFICATION

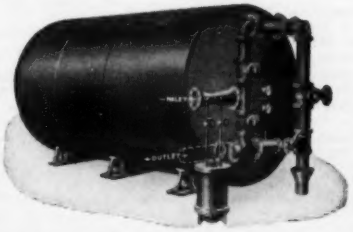


Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

SWIMMING POOL RECIRCULATING SYSTEMS

The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

When you think of good water—think of Roberts Filter

MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO. DARBY, PENNA.

Roberts Filter

Manufacturing Company • Darby, Penna.

(*Continued from page 86 P&R*)

Hussel, Herman, Supt., Water Dept., Box 341, Henderson, Ky. (Apr. '54) *PD*

Hutcheson, Buford Thomas, Sales Engr., Badger Meter Mfg. Co., Box 384, Cookeville, Tenn. (Apr. '54) *MD*

Ilwaco, Town of, W. K. Wheeldon, Water Supt., Ilwaco, Wash. (Corp. M. Apr. '54) *MRPD*

Ingman, Gordon G., Partner, Parker, Hill & Ingman, 1728 E. Madison St., Seattle 22, Wash. (Apr. '54) *D*

Jarstad, Otto, Gen. Foreman, Water Dept., Route 6, Box 3169, Bremerton, Wash. (Apr. '54) *MP*

Jenkins, William O., Supt., Public Works, Box 387, Leaksville, N.C. (Apr. '54) *MP*

Johnson, Robert E., Water Supt., Newport, Wash. (Apr. '54) *D*

Jones, Cyril; *see* Victoria (B.C.)

Jones, Gerald W., Engr., Dept. of Water & Power, 207 S. Broadway, Rm. 701, Los Angeles 54, Calif. (Apr. '54) *MR*

Jones, Howard, Pres., Engineering Construction Corp., Box 525, Logansport, Ind. (Apr. '54)

Keigan, John Albert, Jr., Jr. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *D*

Kelley, Woodrow, Supt., Water Plant, Clinton, Okla. (Apr. '54) *MRP*

Kelsey, George W.; *see* B-I-F Industries, Inc.

Kirkby, Raymond J., Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *PD*

Kirkpatrick, Wilbur, Water Supt., City Hall, Lynden, Wash. (Apr. '54) *MP*

Knowles, Virgil C., City Mgr., Municipal Bldg., Parsons, Kan. (July '54) *MRP*

Kracklauer, A. C.; *see* Sparkler Mfg. Co.

Laubach, Walter J., Chief Operator, Water Plant, Wooster, Ohio (Apr. '54) *MP*

Lieber, Maxim, Assoc. San. Chemist, Div. of Labs. & Research, Nassau County Dept. of Health, 318 Fulton Ave., Hempstead, N.Y. (Apr. '54) *P*

Lindberg, John C.; *see* Marine Drive Water Dist. (Wash.)

Lipp, Charles W., Supt., Spring Valley Water Works & Supply Co., 147 N. Main St., Spring Valley, N.Y. (Apr. '54)

Longpre, Arphile, Asst. Engr., Water Works Dept., 9 Raymond Casgrain, Quebec, Que. (Apr. '54)

Lord, G. Ross, Prof. of Mech. Eng., Univ. of Toronto, Toronto, Ont. (Apr. '54)

Luley, Richard A., Secy., Varner Well & Pump Co., American Trust Bldg., Dubuque, Iowa (Apr. '54)

Luts, Cornelius E., Product Mgr., F. E. Myers & Brother Co., Ashland, Ohio (Apr. '54) *RPD*

Marine Drive Water Dist., John C. Lindberg, Secy., Route 3, Box 1020, Bremerton, Wash. (Munic. Sv. Sub. Apr. '54) *M*

Martin, Waylan C., Mgr., Texas Div., Treat-Rite Chemical Co., Inc., Box 226, Nowata, Okla. (Apr. '54) *P*

Masko, George; *see* Fircrest (Wash.)

Matthews, Harry G., Civ. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *MPD*

McKinlay, Albert W., Controller, Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *M*

Morris, Richard K., Sales Repr., Mueller Co., 2801 E. 12th St., Los Angeles, Calif. (Apr. '54) *RD*

Morse, Daniel P., Exec. Vice-Pres., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Apr. '54) *MR*

Mudge, John B., Pres. & Owner, Chemical Equipment Co. of California, Box 3098, Los Angeles 54, Calif. (Apr. '54) *P*

Newcombe, C. F.; *see* Greater Nanaimo (B.C.) Water Dist.

Owen Sound Public Utilities Com., Robert Butter, Gen. Mgr. & Secy., 1032—2nd Ave. E., Owen Sound, Ont. (Corp. M. Apr. '54)

Parker, Ralph E.; *see* Fairmount (Ind.) Water Works

Payne, Ernest J.; *see* Payne, Ernest J., Water Tank Inspection Service

Payne, Ernest J., Water Tank Inspection Service, Ernest J. Payne, Owner, Box 431, Dallas 1, Tex. (Assoc. M. Apr. '54)

Perez, J. C., Jr., Supt., Water Dept., Box 187, San Diego, Calif. (Apr. '54) *M*

Pike, Robert W., Vice-Pres. & Gen. Mgr., Rankin Newfoundland Co. Ltd., Box 2132, St. John's, Newfoundland (Apr. '54)

Pitts, J., Mgr., Viking Couplings of Canada Ltd., Box 474, Station B, Montreal, Que. (Apr. '54)

Point Edward Public Utilities Com., J. A. Bannister, Mgr., Point Edward, Ont. (Corp. M. Apr. '54)

Princeton Water & Sewer Dept., Roy M. Gresham, Supt., Princeton, Ky. (Munic. Sv. Sub. Apr. '54) *MRP*

Rachar, Clarence C., Mgr., Public Utilities Com., Box 462, Elmira, Ont. (Apr. '54)

Ramsey, Frank, Water Foreman, Water & Light Plant, Hope, Ark. (Apr. '54) *M*

Riddell, James, Central Mortgage & Housing Corp., Ottawa, Ont. (Apr. '54)

Rose City Water Dist., Fred M. Davis, Supt., 4605 N.E. 60th, Portland 13, Ore. (Munic. Sv. Sub. Apr. '54) *MR*

Sappington, Stephen P., Asst. Structural Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *RD*

Schmeichel, Julius, Supt. of Maint., Manlius School, Manlius, N.Y. (Apr. '54) *MRPD*

Smedegaard, M. G., Civ. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *M*

Smith, E. Roy, Supt., River Road Water Dist., 118 Elkay Dr., Eugene, Ore. (Apr. '54) *M*

Sparkler Mfg. Co., A. C. Kracklauer, Pres., Mundelein, Ill. (Assoc. M. Apr. '54)

Stephens, Marvin E., Jr. Civ. Engr., Metropolitan Water Dist. of Southern California, 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '54) *D*

Strapp, Joseph E., Salesman, Harco Corp., 16901 Broadway Ave., Cleveland, Ohio (Apr. '54)

Sylvester, Edward C., Jr., Assoc. Civ. Engr., Dept. of Water Supply, 735 Randolph St., Detroit, Mich. (Apr. '54) *RD*

Thornborrow, John, Mgr. of Public Utility Investments, Northwestern Mutual Life Insurance Co., 720 E. Wisconsin Ave., Milwaukee, Wis. (Apr. '54)

Troxell, Daniel E., Mgr., City Water Co., 111—3rd St., Monongahela, Pa. (Apr. '54) *MP*

Ujcich, Walter; *see* Bessemer (Pa.) Borough Council

Underwood, Roy T., Civ. Engr., Jennings-Lawrence Co., 1392 King Ave., Columbus 12, Ohio (Apr. '54) *RP*

Valentine, George F., Pres., Tract 349 Mutual Water Co., 7325 Atlantic Blvd., Bell, Calif. (Apr. '54) *MD*

Valentine, Louis G., Supt., Tract 349 Mutual Water Co., 7325 Atlantic Blvd., Bell, Calif. (Apr. '54) *MD*

Victoria, Corp. of the City of, Cyril Jones, City Engr. & Water Comr., City Hall, Victoria, B.C. (Corp. M. Apr. '54) *M*

Washburn, Edward A., Mgr., Public Utility Com., 7–9 Ontario St., Stratford, Ont. (Apr. '54)

Watkins, S. C., Partner, A. D. Harvey & S. C. Watkins, 12 Goldy Bldg., Medford, Ore. (Apr. '54)

Watson, William B., San. Engr., Dept. of Health & Welfare, City Hall, Halifax, N.S. (Apr. '54) *P*

Whealdon, W. K.; *see* Ilwaco (Wash.)

Whitcomb, Walter E., Sales, Beall Pipe & Tank Corp., 12005 N. Burgard, Portland, Ore. (Apr. '54)

White, Claude, Jr., Civ. Engr., Jennings-Lawrence Co., 1392 King Ave., Columbus 12, Ohio (Apr. '54) *PD*

Wilkinson, G. L., Secy. & Acting Mgr., Water Works Board, City Hall, Evergreen, Ala. (Apr. '54) *M*

Williams, Willis F., Meter Shop Foreman, Water Div., Utilities Dept., 27 Artesian St., Houston, Tex. (Apr. '54) *M*

Wilson, Forrest G., Utilities Supt., Box 25, Brewster, Wash. (Apr. '54) *MD*

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Contractors can use standard equipment and semi-skilled labor to lay reinforced concrete pipe. Joint closure is simple and economical. Rubber gasket joints provide a safe, positive closure and eliminate costly welding or caulking.

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Section Meetings

Nebraska Section: The eighth annual meeting of the Nebraska Section was held Apr. 22–23 at the Cornhusker Hotel, Lincoln, with approximately 200 persons attending. Once again the meeting was conducted jointly with the Utilities Section of the League of Nebraska Municipalities. An excellent Ladies' Program was prepared by Mrs. John W. Cramer, but disappointingly few women came to take advantage of it. It is believed that ample rain during the approaching growing season will improve the ladies' attendance next year.

To everyone's satisfaction, John W. Cramer of the firm of Fulton & Cramer, consulting engineers, was nominated to receive the Fuller Award.

This year, for the first time, the Nebraska Section boasts a 30-year man—Dave L. Erickson, Fuller Awardee and past director, who is the director of public improvements and city engineer of Lincoln. Frank Amsbary, AWWA vice-president-elect, presented the certificate.

At the banquet, the Chairman's Certificate of recognition and appreciation was bestowed upon Charles B. Elliott, the outgoing chairman. He did a fine piece of work this year and the Section shows it.

The water works technical program included papers on "Swimming Pools and Their Operation" by Ralph N. Perkins Sr., Omaha; "Coordination of City Mapping With Aerial Photography for City Planning" by George R. Miller, manager, Board of Public Works, Beatrice; "City Ownership and Maintenance of Water Meters" by Dave R. Hill, superintendent, Water & Light Dept., Hastings; "A Planned Water Department Safety Program" by Earl Frederiksen, supervisor of health and safety, Metropolitan Utilities Dist., Omaha; "Utilities Versus Streets" by Stanley A. Michael of Kirkham, Michael & Assoc., and "Procedures for Maintenance Painting" by Albert Kimmel of the Tnemec Co., North Kansas City, Mo. A "Bull Session" was conducted by Bill Wright, assistant superintendent of utilities, Fremont.

E. Bruce Meier
Secretary-Treasurer

South Dakota Short Course: A water works operators short course sponsored by the State Dept. of Health, the South Dakota Water & Sewage Works Conference, and South Dakota State College was held April 12–14 at State College, with 42 persons in attendance. The short course is a biennial feature, with one-day meetings on specialized subjects held in the odd years. Among topics covered by the course were fire protection, main disinfection, landscaping, fluoridation, bacteriology, activated silica, and meter maintenance.

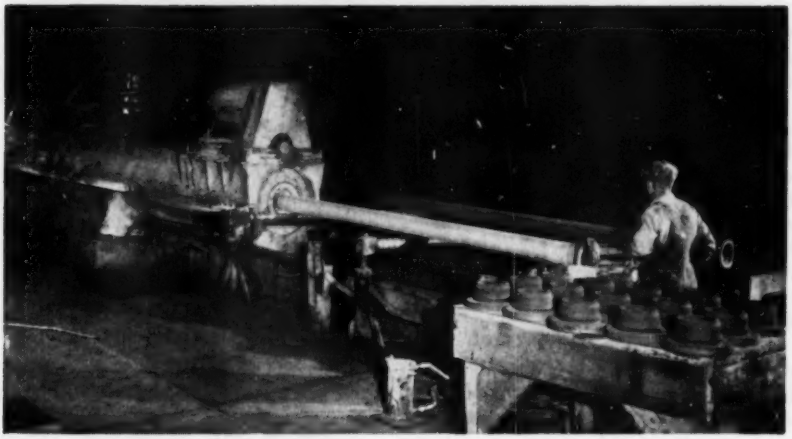
Garry L. Fisk
Dept. of Civil Engineering

Canadian Section: The 34th Annual Convention of the Canadian Section held at the Royal York Hotel in Toronto on April 12th to the 14th brought out the highest registration of all time—848. All sessions were well attended, and there was keen interest shown in the program, inspection trips, and social events.

Officers elected for the ensuing year were: Chairman—C. S. Anderson, South Porcupine, Ont.; Vice-Chairman, A. H.

(Continued on page 92 P&R)

PIG IRON *with a* HOLE IN IT!



Close-up view of pulling a pipe from centrifugal casting machine.

WHY McWANE-PACIFIC CAST IRON PIPE *LASTS for CENTURIES*

Cast Iron Pipe is an engineering product. But the "wag" who jokingly said that Cast Iron Pipe was a "chunk of pig iron with a hole in it" probably spoke with more wisdom than he realized.

Production of pig iron is the first step in refinement of iron ore. As everyone knows, iron ore has laid in the ground for untold ages of time, without rust or corrosion. The more iron is refined, the more subject it is to rust and deterioration. The less it is refined, the more durable it remains. That is why McWane-Pacific Super DeLavaud cast iron pipe, ("pig iron with a hole in it") lasts for centuries.

For details, wire or write McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama, or PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)

McWANE PACIFIC PIPE *Lasts for Centuries*

Section Meetings

(Continued from page 90 P&R)

R. Thomas, New Toronto, Ont.; Trustees, L. B. Allan, Toronto, Ont., and W. R. Godfrey, St. John, N.B.; and Secretary-Treasurer, A. E. Berry, Toronto.

The program was divided between written papers and guided discussions. Attention was focused by two papers on conditions in the newly created municipality of Metropolitan Toronto. The first paper, given by L. B. Allan, commissioner of works, dealt with the "Supply and Distribution of Water in Metropolitan Toronto." The second paper, by R. L. Clark, deputy commissioner of works, dealt with the maintenance of the various public utilities services during construction of the Yonge St. Rapid Transit Subway, which was completed last March.

T. R. B. Watson, corrosion engineer of Toronto, presented a paper on cathodic protection, illustrating the methods used for protecting pipelines and other structures. A paper on "Water Supply for Distant and High Level Areas," prepared by W. L. McFaul, city engineer, and James Stodart, designing water works engineer, Hamilton, Ont., was read by the latter. The final paper, entitled "Survey of Recent Canadian Water Treatment Installations," was prepared by A. E. Berry and G. M. Galimberti of the Ontario Dept. of Health (*see* this issue, p. 684).

Guided discussions have always been prominent in the program of the Canadian Section, and there were four this year, all dealing with current problems in water works administration. A series of questions for each subject had been prepared and distributed to the members with the result that there was a free exchange of information and ideas among those present.

At the business session of the convention, two committee reports were conspicuous. The first dealt with water works schools and certification of plant operators. The meeting approved of a recommendation that all provincial departments of health in Canada be asked to develop short courses of instruction leading to certification of employees.

The second committee report dealt with the future status of the section in respect to administrative procedure. The growth of the section to a membership exceeding 600, combined with the publication of the *Water Works Information Exchange*, has made it desirable to establish a separate office with a full-time secretarial assistant. It is proposed to operate this office jointly with the Canadian Inst. on Sewage and Sanitation. In order that this program may be carried out, some constitutional

(Continued on page 94 P&R)

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Longer lasting INERTOL PAINTS *specified* at Miami water works

Sure protection for this new 4,000,000-gallon ground storage reservoir at Miami's Southwest Water Treatment Plant was provided by Inertol coatings. Here, painters apply finishing coats of Inertol No. 49 Thick to back wall. Note smooth, lasting seal on finished wall at left.

Department of Water and Sewers finds Inertol coatings meet exact requirements

• When the Department of Water and Sewers, of the City of Miami, Florida, wanted paints that would deliver long-range durability plus chemical inertness, they specified Inertol coatings. They found that this Inertol bituminous painting system fully met their specifications for elasticity, hardness and water-resistance. The Department knew because of the coatings' inertness, that the Inertol paint on this huge storage reservoir would not impart taste or odor to drinking water. On other installations, they have specified many other Inertol coatings, including chemical-resistant colored enamels.

In thousands of installations all over the United States, Inertol Paints have proved their superiority and long-run economy. Learn the full story on how Inertol coatings can fit your precise need—ask to have an Inertol Field Technician call. Or send for our "Painting Guide" today. You'll find this pamphlet invaluable if you're a Specification Writer, Design Engineer, Plant Superintendent, or Contractor. Write for your free copy today!

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Section Meetings

(Continued from page 92 P&R)

change in respect to the parent association has been proposed. Ways and means are being studied to achieve this objective.

Inspection trips were made to the purification plants of Scarborough Township and New Toronto as well as the manufacturing plants of the National Iron Works, Johns-Manville Co., Wallace and Tiernan, and Neptune Meters Ltd.

The annual banquet, attended by more than 700, was the occasion for presentation of awards and honors. These consisted of: the Past-Chairman's Certificate, to W. D. Hurst, Winnipeg; the chairman's memento of office to C. G. R. Armstrong, Windsor; the Fuller Award nomination to A. U. Sanderson, Toronto; Life Membership certificates to W. L. McFaul, Hamilton; J. P. McRae, Toronto; M. Pequegnat, Kitchener; and A. H. R. Thomas, New Toronto; the Hunt Award for proficiency in operation to Harry C. Mills, Belleville; and, finally, membership certificates for a large number of members who had held continuous membership of either 15, 20, 25, or 30 years in the Association.

Once again the Water Works Club proved successful as a means of keeping the delegates together for relaxation and enjoyment. It is sponsored by the Canadian Water Works Equipment Assn., which also provided entertainment for the guests following the banquet.

A local committee convened by Mrs. J. B. Kinney and Mrs. N. MacNicol was responsible for an enjoyable visit by the large number of ladies who were present.

A. E. BERRY
Secretary-Treasurer

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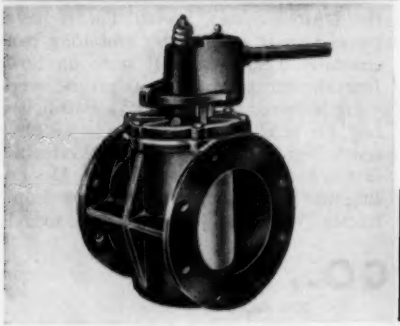
PLUG VALVES
Exactly Right
FOR WATERWORKS JOBS



OUT OF ALL their hundreds of uses, DEZURIK VALVES seem literally tailor-made for waterworks services. Their rubber-faced plugs achieve the surest, tightest shut-off on the busiest lines . . . sand, grit or scale can't clog or distort them . . . they need no lubrication, no adjustment, no reseating. Exclusive ECCENTRIC ACTION opens these valves fully or closes them drip-tight in an easy quarter-turn, never binding or sticking.

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DeZurik Valves in sizes ½" thru 20"; manual or remote operation. Write for details.

NO NEED
to specify over-sized pipe . . .

NO WORRY
over low flow capacity . . .

NO NEED
to buy bigger and bigger pumps . . .

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Pipe lines don't "shrink" when the interior surfaces are coated with a spun lining of Bitumastic 70-B Enamel . . . because this durable enamel *prevents* rust, corrosion, incrustation and tuberculation.

When the inside diameter of your pipe line *stays* the same through the years, you select pipe solely on the basis of desired capacity. You don't waste money by specifying *over-sized* pipe in order to allow for future "shrinkage." When your pipe line's coefficient of flow *stays* high, you don't have to replace pumps with bigger ones that cost more to buy and operate.

Bitumastic 70-B Enamel is equally effective in protecting exterior surfaces of pipe lines. It prevents pitting and leakage caused by soil corrosion. Give your steel pipe lines *lasting* protection, inside and out, with Bitumastic 70-B Enamel. Write for details.

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Service Lines

A "Glossary of Terms" and a "Hoist Classification Chart" have been issued by the Hydraulic Hoist and Steel Dump Body Manufacturers Assn., 1740 K St., N.W., Washington 6, D.C. The two documents provide a standard terminology and standardized capacity ratings for the industry.

Domestic water softening is being promoted by a booklet, "Invitation to More Leisure," being distributed by Dow Chemical Co., Midland, Mich. The pocket-size pamphlet offers a layman's description of hardness, its effects upon housekeeping activities, and the value of domestic water softeners, whether purchased outright or provided on a rental-service basis. Those who operate municipal softening plants will be interested in learning that the Dow people recommend domestic softeners to bring the hardness level down still further to a point below proximately 50 ppm.

Flow meters—indicating, recording, integrating, and controlling—are described in a 56-page fully illustrated catalog, No. 2320, of Minneapolis-Honeywell Regulator Co. Specifications, installation information, and a table to aid in selection are included. Copies may be obtained from Station 64 of the company at Wayne & Windrim Aves., Philadelphia 44, Pa.

"Ball Valves by Smith" describes a new line of manually operated valves now available in sizes from 12 to 48 in. Copies of Bul. 159 may be obtained from the Valve Div., S. Morgan Smith Co., York 8, Pa.

Demineralizers for various purposes are described in a 24-page booklet, Bul. WC-111, distributed by Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y. Associated equipment for automatic or semiautomatic sequence operation is included.

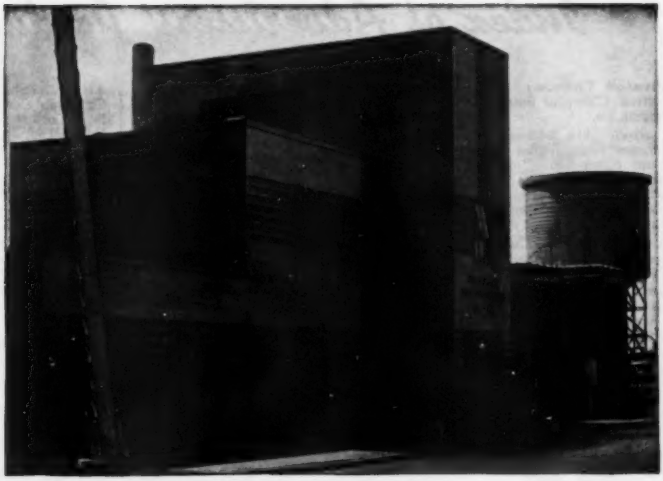
Continuous turbidity measurements using a combination of General Electric turbidimeter and Minneapolis-Honeywell recorder are described on Instrumentation Data Sheet 10.14-5a, available from Station 64, Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa.

Continuous softening with the Dorrco Hydro-Softener is described in Bul. 4083 of The Dorr Co., Barry Pl., Stamford, Conn. The unit employs a compartmentalized softening cell and a smaller regeneration cell, in which the ion exchange resin is continuously being regenerated by brine.

Valves and hydrants of Rensselaer Valve Co., Troy, N.Y., are described and illustrated in a 12-page booklet, Bul. M-2, which is available on request. Gate, check, square bottom, and air release valves are included, together with gearing combinations, air and cylinder operation, and other accessories.

Sequence operation for the semiautomatic backwashing of filters is the subject of Bul. 480-L1, entitled "Auto-Central Filter Control," of Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. The system utilizes control equipment to indicate, by means of a loss-of-head gage, the need for backwashing. Remotely operated valves carry out the backwashing operation automatically.

Tank cleaning by the use of chemical solvents is described in a folder entitled "Look to Dowell for Effective Tank Cleaning." Copies may be obtained from Dowell Inc., Box 536, Tulsa 1, Okla.



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Because of high Precipitator efficiency, each filter is backwashed only once a week for 20 minutes. "The Precipitator has not given any trouble. The Permutit filter is one of the best . . . has been trouble-free", adds Mr. Klang about this 1939 Permutit installation.

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Staples' compact Permutit Precipitator has 400 gpm capacity. Softens hard well water, removes turbidity, iron, and manganese.

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Morse Bros. Mchy. Co.

Alum (Sulfate of Alumina):
American Cyanamid Co., Industrial Chemicals Div.
General Chemical Div.

Ammonia, Anhydrous:
General Chemical Div.

Ammoniators:
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Carbon Dioxide Generators:
Infilco Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Electro Rust-Proofing Corp.
Harco Corp.

Cement Mortar Lining:
Centriline Corp.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.

Chemical Feed Apparatus:
Cochrane Corp.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Precision Chemical Pump Corp.
Proportioneers, Inc.
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Chemists and Engineers:
(See Prof. Services, pp. 25–29)

Chlorination Equipment:
Builders-Providence, Inc.
Everson Mfg. Corp.
Fischer & Porter Co.
Proportioneers, Inc.
Wallace & Tiernan Inc.

Chlorine Comparators:
Klett Mfg. Co
Wallace & Tiernan Inc.

Chlorine, Liquid:
Wallace & Tiernan Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
McWane Cast Iron Pipe Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
Skinner, M. B., Co.
A. P. Smith Mfg. Co.

Clamps, Bell Joint:
James B. Clow & Sons

Dresser Mfg. Div.
Skinner, M. B., Co.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Skinner, M. B., Co.

Clarifiers:
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Cochrane Corp.
Dorr Co.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Sales Corp.
National Water Main Cleaning Co.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
General Filter Co.
Infilco Inc.
Simplex Valve & Meter Co.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Phelps Dodge Refining Corp.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Philadelphia Gear Works, Inc.

Diaphragms, Pump:
Dorr Co.
Morse Bros. Mchy. Co.
Southern Pipe & Casing Co.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 25–29)

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Belco Industrial Equipment Div.
Calgon, Inc.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
General Filter Co.
Johns-Manville Corp.
Infilco Inc.
Northern Gravel Co.
Permutit Co.
Carl Schleicher & Schuell Co.

Filters, Incl. Feedwater:
Cochrane Corp.
Dorr Co.
Infilco Inc.
Morse Bros. Mchy. Co.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Roberts Filter Mfg. Co.
Welsbach Corp., Ozone Processes Div.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
American Cast Iron Pipe Co.
American Locomotive Co.
Carlon Products Corp.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr Co.
General Filter Co.
Infilco Inc.
Permutit Co.

Fluoride Chemicals:
American Agricultural Chemical Co.
Blockson Chemical Co.
Henry Sundheimer Co.

Fluoride Feeders:
Builders-Providence, Inc.
Omega Machine Co. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
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Infilco Inc.
Northrop & Co., Inc.
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FOR "Flexibles" AT SANDFORD, MAINE

From Sandford, Maine, to San Diego, California—from Seattle, Washington, to Miami, Florida, "Flexible" Equipment provides the answer to general and specific sewer-cleaning problems.

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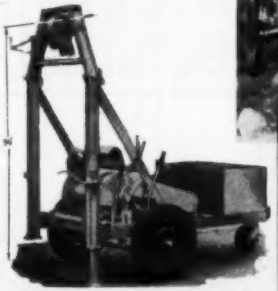

This photograph was taken some years ago. Since then "Flexible" Bucket Machines have been importantly modernized and improved in line with our constant study of sewer-cleaning needs and advanced engineering methods. We invite an "on the job" demonstration.

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Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

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Builders-Providence, Inc.
Hersey Mfg. Co.
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Crane Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

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Pumps, Turbine:
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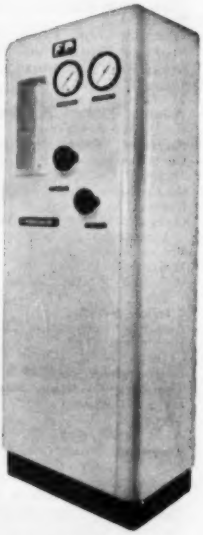

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Tapping Machines, Corp.:
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Dorr Co.
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Zeolite; see Ion Exchange Materials

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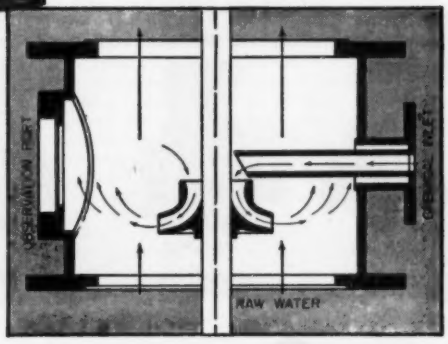
American HOMOMIX CHEMICAL MIXING without a Mixing Tank

2-stage Homomix

The HOMOMIX gives instantaneous, violent, and uniform mixing of one or more chemicals, or gases, with water. *Immediate, total diffusion*—the most important factor for the efficient and economical addition of chemicals or gases—is obtained *without the use of a mixing tank!* For new plants it eliminates the necessity for costly mixing tank construction; for existing plants it can be effectively used to improve treatment.

The HOMOMIX, in one or more stages, is installed in, and forms part of, the piping. Diffuser impellers rotate in blending chambers and discharge directly across the flowing-through stream. Each chamber has one or more chemical inlet connections and a transparent plastic observation port through which the mixing action is visible. A lifting stage can be provided for additional head, if required.

Write for "Technical Supplement HM" . . . Complete Design Data



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Our staff of Sanitary Engineers will cooperate with consulting and operating engineers in suggesting the process of treatment and type of equipment best suited to individual needs.

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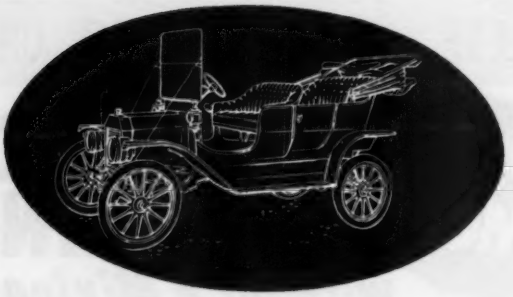


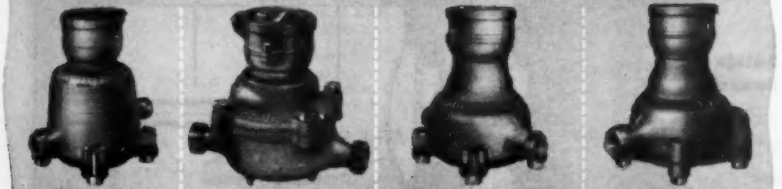
Would you keep on repairing a 1912 car?

There are many thousands of meters purchased thirty or more years ago still in service. They are being periodically repaired—frequently rebuilt from the old meter case up. This practice can impose a tremendous burden of trouble and expense on a water utility, especially at today's higher labor rates.

Many management men, with an eye towards costs, know these facts. They know that a new Rockwell meter will measure 95% of the ¼ gpm or smaller flows as against 90% or less for a repaired meter. They realize that if the cost of repairing an old meter amounts to half the cost of a new meter, they are better off to buy a new one.

Here at Rockwell we've worked constantly for improvement and our meters show it. They will measure at top accuracy for longer periods at lower costs. You can buy them with full confidence in their ability to cut your operating and maintenance costs and increase your revenue.

Rockwell Modern Meters For Modern Measurement Needs



ARCTIC	TROPIC	EMPIRE TYPE 12	EMPIRE TYPE 14
Disc Type	Disc Type	Piston Type	Piston Type

The Symbol for Service, Quality and Performance in Water Meters

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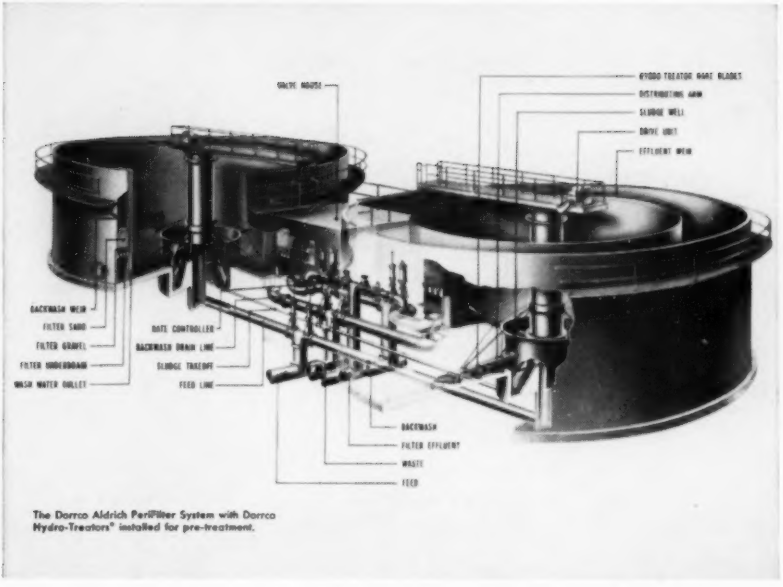

The Dorrco Aldrich PeriFilter System with Dorrco Hydro-Treators® installed for pre-treatment.

New System Cuts Water Filtration Plant Construction Costs Up to 40%

Would you like to realize savings up to 40% in filtration plant construction costs . . . and at the same time get improved operation compared with conventional methods? Both are now possible with the Dorrco Aldrich PeriFilter System. A single PeriFilter consists of a Dorr pre-treatment mechanism surrounded by an annular rapid sand filter and two or more of these dual units are usually manifolded to form the System.

Here's how the PeriFilter cuts costs . . . A unique design permits installation of both pre-treatment unit and filter in the same tank. Valves and piping are greatly simplified. Reduced head losses and simple operation add up to lower operating costs.

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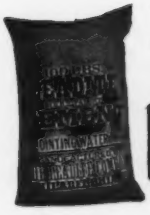

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